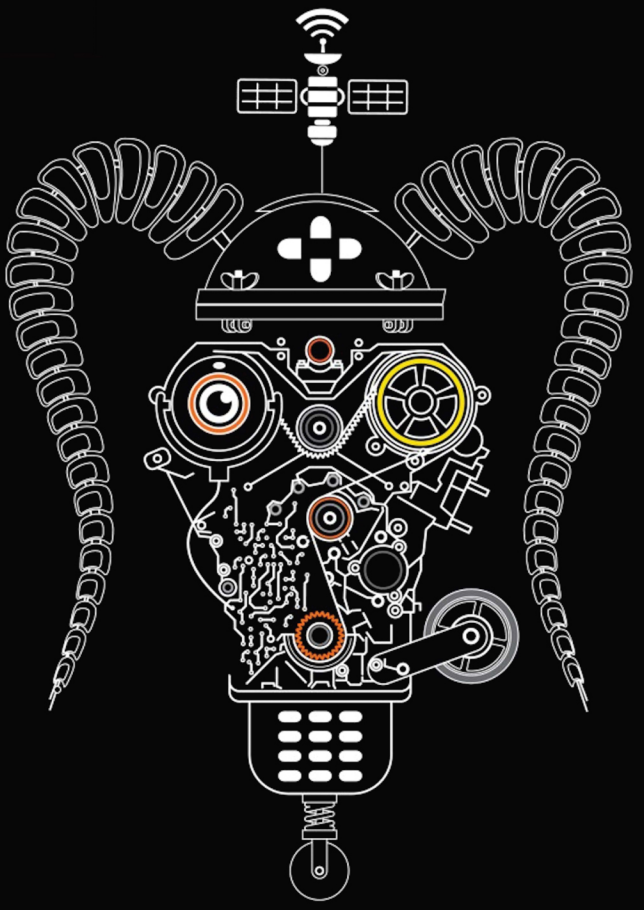
What Do Science, Technology, and Innovation Mean from Africa?



edited by Clapperton Chakanetsa Mavhunga

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What Do Science, Technology, and Innovation Mean from Africa?

Edited by Clapperton Chakanetsa Mavhunga

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Cambridge, Massachusetts
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For Mamadou Diouf, my professor and mentor, a selfless man gifted with boundless generosity and inspiration.

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Contents

Preface ix

Introduction: What Do Science, Technology, and Innovation Mean from Africa? 1
Clapperton Chakanetsa Mavhunga

1 The Place of Science and Technology in Our Lives: Making Sense of Possibilities *29*
D. A. Masolo

2 The Language of Science, Technology, and Innovation: A *Chimurenga* Way of Seeing from *Dzimbahwe* 45
Clapperton Chakanetsa Mavhunga

3 The Metalworker, the Potter, and the Pre-European African "Laboratory" *63*
Shadreck Chirikure

4 Plants of Bondage, Limbo Plants, and Liberation Flora: Diasporic Reflections for STS in Africa and Africa in STS *79*
Geri Augusto

5 Smartness from Below: Variations on Technology and Creativity in Contemporary Kinshasa 97
Katrien Pype

***6* On the Politics of Generative Justice: African Traditions and Maker Communities 117**
Ron Eglash and Ellen K. Foster

***7* Making Mobiles African 137**
Toluwalogo Odumosu

8 Innovation for Development: Africa 151
Garrick E. Louis, Neda Nazemi, and Scott Remer

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9 Science, Technology, and Innovation in Africa: Conceptualizations, Relevance, and Policy Directions 169
Chux Daniels

References 187
Contributors 225
Index 227

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Preface

This book is the culmination of a long-held dream to one day assemble a stellar team of mentors and colleagues to discuss a burdensome question: What do science, technology, and innovation mean from Africa? Put another way: What is Africa in science, technology, and innovation on the one hand, and what are science, technology, and innovation in Africa on the other?

The rationale for asking this question is that Africa appears on the technological map of the world as a blank or as a problem—in fact, as an oceanful of problems—to be solved. But solved by whom? It was very clear to me at the turn of the century that science, technology, and innovation seemed to be things inbound from somewhere outside Africa, usually the West—hence the whole notion of technology transfer as a North to South or West to non-West flow that would *finally* lift the continent up the development ladder in the hope that perhaps, one day, Africa would be developed. Therefore, the basis of the conversation about Africa was that it was a recipient of science, technology, and innovation, not a maker of them.

One cannot answer these difficult questions alone; it takes a village to raise a child. I have never believed in any one method; I believed even less that the European colonial academic traditions that have trapped the production of knowledge about Africa are enough—as free-standing disciplines, each aloof from the other—to even attempt to address the questions stated earlier. As an African scholar trained in science, technology, and society (STS) and African history, I believe in the necessity of having many eyes—a multiple optic—that looks at the same question, the same thing, from different viewpoints. For this book, the only requirement was that all of these many pairs of eyes should concentrate on African ways of looking, meaning-making, and creating and should take Africans as intellectual agents whose perspectives constitute authoritative knowledge and whose actions constitute strategic deployments of endogenous and inbound things.

I had in mind not simply using African voices as empirical fodder for us to then bring in Marx, Foucault, Derrida, Kant, or other (normally) Western scholars to order these voices into knowledge about Africa. In *The Idea of Africa*, V. Y. Mudimbe (1994) traced this

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placement of a "Western ratio" at the center of ordering knowledge about Africa. He threw down the gauntlet right at our feet: Could it be possible to decenter the West and recenter African modes of thought?

Thus my hope was to assemble scholars who could go beyond critique—which Mudimbe did not do—by taking African knowledge seriously as epistemology on its own terms, and who could consider themselves (at least those contributors who are Africans by birth or descent) engaged in offering an African perspective. The latter meant that the force of argument was derived from an African point of view, with inbound epistemologies not forming the foundation of but rather constituting ingredients for an Africa-centered position. For scholars that were non-African, I was looking for colleagues who take African innovations and registers seriously enough to expunge Marx, Foucault, or other Western ratios from the base and spine of their argument—indeed, to use African vernaculars as modes of theory, even if they then engaged Western modes of thought and practice.

The question thus became one of methods. What archives could we defer to? How could we read them not simply as sources for our own writing and authority, as scholars like Jan Vansina, Henry Odera-Oruka, and Ngugi wa Thiongo had done in their albeit groundbreaking work, but as African modes of writing and authoritative philosophical texts in their own right? And given that most of these archives were simultaneously philosophies that had never been taken at their own value but were always filtered through the Western weighted scale of what is epistemology, philosophy, "proper historical sources," and so on, how then should we approach them? How could we acknowledge the way in which writing is no longer pen to paper, or inscriptions on stone, wood, or human body, but the everyday mobilities that transform the human body and mind into the pen at large, inscribing what's around it with marks?

These questions had decisive implications for the methods of assembling a team to address them. I could not gather all these scholars into one room at once, precisely because of the colonial disciplinary legacies of the production of knowledge about Africa discussed earlier, in which the language of engagement is normally barracked into anthropology, history, geography, philosophy, engineering, and so forth. The task of assembling a team to address these questions had to be piecemeal and, even after this volume, continue to be refined and expanded, particularly because my intention has always been not only to produce usable knowledge, but to intervene practically in advancing Africa's future through introducing multidisciplinary understandings of science, technology, innovation (and lately entrepreneurship) in society.

The first scholar I decided to include to meet this goal was D. A. Masolo, whose works had first been pointed out to me by my mentor, Mamadou Diouf, during his Reading African Libraries graduate seminar at the University of Michigan, Ann Arbor. Mamadou has this cunning habit of throwing around names that students who are serious about African intellectual history can follow up. That is how I was able to read Aime Césaire, Leopold Senghor, Kwame Nkrumah, W. E. B. Dubois, Frantz Fanon, Paulin Hountondji, Henry Odera-Oruka,

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John Mbiti, Okot p'Bitek, Alexis Kagame, Ernest Wamba dia Wamba, Bogumil Jewsiewicki, Ivan Karp, George Shepperson, Kwasi Wiredu, Chinweizu, Adrian Hastings, Achille Mbembe, Paul Tiyambe Zeleza, Mahmood Mamdani, and Ngugi wa Thiongo. And, of course, D. A. Masolo, whose critique was that Ngugi, Odera-Oruka, and Vansina did not go far enough and left open—after negritude, after Pan-Africanism, after African socialism, and even after the "sage philosophy" that Odera-Oruka actively promoted—the search for new archives and modes of African philosophy. I approached these scholars as a learner, and I was looking to apprentice in the African way, in which elders impart knowledge to the young at close quarters.

The debt I owe to Mamadou Diouf for helping me understand the context of the question of the scientific and the technological in Africa from a combined philosophical, historical, contemporary, diagnostic, and prognostic perspective is, quite simply, unpayable. After my textual and face-to-face interactions with the above-mentioned scholars, it became quite clear that the issue at stake for the African reader of technology, the reader of technology in Africa, and better yet African technology, is not just the behavior of science, technology, and innovation but the intellectual work of making things and their strategic deployment. Can one see Africans as intellectuals thinking about and making technology based on intellect?

This question was an acknowledgement of what I had witnessed in everyday interactions with people in different parts of Africa, but even more so during my own childhood in Zimbabwe. In people's mobilities I saw an archive, a statement, a critique, and an authoring of thought into reality through practice, operationalized through the movement of legs, hands, mouth, and other body functions. I wanted to locate the subject of conversation upstream of practice, to understand the intellection that drove it. Some micro-movements of and within the body were involuntary; the concern was with the voluntary actions, delegated by the mind-at-work.

STS had prepared me to understand one version of science and technology, to recognize it when I saw it. This was a vital skill—but it also turned out to be quite blunt for the nature of knowledge I was looking at. Conventional (Western) STS is good at identifying banal forms of science and technology but is severely limited in non-Western contexts, in which things scientific and things technological are not readily recognizable.

Here was the problem in the specific case of Africa. The project of addressing the meanings of science, technology, and innovation from Africa had to be philosophically grounded, because to my understanding the colonial ordering of knowledge had cut up African knowledge, knowledge production, and structures and modes of knowing into tiny pieces. What had once been a whole entity known as a composite was now scattered into specialist disciplines like philosophy, theology/religious studies, African languages and literature, history, economic history, anthropology, and so on. The philosophy I remember being taught in the University of Zimbabwe in the early 1990s was about Socrates, Plato, Aristotle, Kant, Marx, and so on. *Where were the Africans?*

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The history I was taught was simply a subject; it was absolutely useless for addressing the everyday life I lived as an African or helping me solve anything. History as taught in school and college was—and still is—utterly elitist and decontextualized, to the extent that it is in danger along with most "arts and humanities" of becoming completely irrelevant for us as Africans. It is not enough to know where we came from, to learn the phonetic arrangement and diction of our languages, or to study theology to earn a degree or teach after graduation. This knowledge is disemboweled into pieces, yet it used to be one whole, inextricable from the practices and sites of production by which it was taught. That is why Masolo had to be present at the MIT workshop; that is why Mamadou Diouf had to be there.

The conversations with Mamadou began in grad school, but those with Masolo started in 2012. I was co-organizing the STS Colloquium with my colleague Michael Fischer, and we found ourselves converging on Masolo, whom Mike knew well from their time at Rice along with another emblematic Kenyan scholar, the late Atieno Odhiambo. We had wonderful conversations. The encounter was to be the beginning of a continuing conversation that endures to the present. Most recently, I have fulfilled my dream to pull together African philosophers and STS scholars, especially my PhD advisor Gabrielle Hecht and those African scholars whose work intersects with and has indelibly shaped my own. The result was the highly successful Anthropocene Campus seminar that I organized at the Haus der Kulturen der Welt (HKW) entitled "Whose? Reading 'The Technosphere' and 'The Anthropocene' from Africa." The seminar included lectures from Gabrielle (STS), Masolo (philosophy), Chaz Maviyane-Davies (graphic design), and Shadreck Chirikure (archeology).

The intellectual exchange that resulted in Chirikure's contribution to this volume occurred during a workshop I convened at the University of the Witwatersrand in 2014 during my three-year tenure as an inaugural Carnegie African Diaspora Fellow (CADF). Entitled "African Laboratories, Laboratories in Africa, Africans in Laboratories," the workshop sought to explore meanings and practices of *laboratory* from African experiences, departing from its association with the built space, bench science, and, even where bench science was involved, in the hands and minds of Africans. Besides Chirikure (University of Cape Town, paper on pottery and metallurgy), participants also included Lauren Hutchinson (London School of Hygiene and Tropical Medicine, on Kenya's first post-independence scientists attempting to decolonize malaria research and make it more responsive to local needs and knowledge) and Peter Sekibakiba Lekgoathi (Wits, on African intellectuals whom colonial ethnologists and anthropologists employed as and called *research assistants* despite the "assistants" performing all the research and even authoring certain texts). Dilip Menon, director of the Centre for Indian Studies in Africa, chaired the workshop, which was well-attended beyond Wits. Chirikure's paper and my introduction (this volume) were presented at this energetic workshop in the Senate Building.

The Wits workshop anticipated a second one I had finalized for MIT with generous funding from the Program in Science, Technology, and Society and the Dean's Office in the School of Humanities, Arts and Social Sciences. David Kaiser and Deborah Fitzgerald were

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the director and dean at the time, respectively, and appreciated the importance of the question—the title of this book—in the global discussion in STS. The workshop, held over two days, November 13–14, 2014, was a culmination of a long process of identifying colleagues from different fields of enquiry and bringing them under one roof to engage in what Zimbabweans call *kuonesana*—helping each other see from perspectives besides one's own.

I had met these colleagues separately and individually; many were seeing each other for the first time. Gillian Marcelle (innovation policy) had facilitated my visiting professorship at Wits, and we shared a passion for innovation policy in the present. Katrien Pype (anthropology) had spent a year on a Marie Curie fellowship in the Program in STS at MIT, and we had also convened a successful workshop on "Technology and Mobility in Africa" at KU Leuven in October 2013. Also, we had begun to think of a special section for the new mobilities journal *Transfers*. I had never met Gloria Emeagwali (history), but had read her work and actively followed her attention to indigenous knowledge as a historian. Kristin Peterson (anthropology) was already a friend of many years dating back to the University of Michigan, when I was a graduate student and she was starting out as an assistant professor at Michigan State University. We used to sit for hours in Espresso Royale on State Street, Ann Arbor, discussing Africa over coffee. She had suggested that Olufunmilayo Arewa (law), her colleague at UC Irvine, would bring a needed perspective to the volume. Toluwalogo Odumosu (engineering/STS) was introduced to me by Garrick Louis (engineering and public policy), whom I had met at the Brown International Advanced Research Institutes (BIARI) summer school in 2013. The person who had invited us both was Geri Augusto (international and public affairs and Africana studies). I had read cyberneticist Ron Eglash's work on African fractals in graduate school, and it had given me confidence that the questions I was asking were not cuckoo. Ellen Foster (STS) was his student at RPI. Alvan Ikoku (comparative literature/medicine) was doing interesting work on Kenyan literatures. Rudo Mudiwa was a graduate student at Indiana University, one to watch for the future but who was still at an early stage in conceptualizing her project. Mamadou Diouf and Masolo were supposed to attend, but personal circumstances robbed us of their much-anticipated presence.

There was good attendance—from colleagues in the Program in STS and beyond. Rosalind Williams gave the welcoming address. Michael Fischer was there from start to finish, as were Abha Sur and Hanna Shell. Many graduate students were in attendance, not least the members of the memorable Introduction to Science, Technology, and Society course I had the pleasure of teaching in 2014. In particular, I wish to thank Peter Oviatt and Ashawari Chaudhuri for helping Judy Spitzer and Randyn Miller with the logistical work. This is also a project first conceived while Marguerite Avery was an acquisitions editor at the MIT Press and that Katie Helke is seeing off wonderfully into publication. This project would be impossible to achieve without a department and school in which if one has good ideas that advance STS in new directions, no effort is spared to realize them.

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All in all, the biggest challenge of bringing together diverse voices steeped in their disciplines and practices is that it shakes every participant out of their comfort zone. Sometimes it can lead to heated argument. Yet the reason I enjoy bringing people together from diverse cultures of doing things is exactly that: to avoid knowledge production becoming an echo chamber, and to set up a vibrant multi-optic crucible within which new ideas are forged. For that I pay homage to everyone who participated in the MIT workshop.

As you can tell from the table of contents, not all of the papers from both the Wits and MIT workshops made their way into this book. This was in no way due to a lack of quality but to sticking to deadlines democratically agreed to at the end of both workshops. There was also an editorial question to address of striking a balance between the disciplines represented at both conferences.

It was through Gillian Marcelle that I was able to meet Chux Daniels of the University of Sussex Policy Research Unit (SPRU). On November 28, two weeks after the 2014 MIT workshop, Gillian convened a panel to discuss Africa's development blueprint: Science, Technology, and Innovation Strategy for Africa (STISA). At the time, she had just taken up what turned out to be a brief venture as deputy executive director (DED) in the Centre for Science, Technology and Innovation Indicators (CESTII) in South Africa's Human Sciences Research Council (HSRC). The workshop included, among others, Daan du Toit (deputy director-general for international cooperation and resources in the South African Department of Science and Technology), David Ockwell (deputy director of research at Social, Technical and Environmental Pathways to Sustainability [STEPS] UK), Hambani Masheleni (African Union Commission), and Chux Daniels, who was then finishing his PhD at SPRU. This workshop was also my introduction into science and technology policy circles in Africa.

Gillian Marcelle was supposed to write the chapter on policy for this book, but she was still settling in as the executive director of Research and Technology Park in the British Virgin Islands. Therefore, Chux stepped in to take her place—thus mitigating what was a potentially big loss. Since the HSRC workshop, Chux and I have since continued the conversation, co-convening a successful workshop at the Institute of Development Studies at the University of Sussex in 2015. We are currently editing and transcribing the video footage, with the aim of coauthoring a book on the diaspora in science, technology, and innovation policy and numerous multimedia products. The chapter from Chux crystalizes where we are in terms of the state of debate on the subject; the book seeks to go beyond critique to show how the African diaspora could be positioned as a serious factor in Africa's prosperous future.

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Introduction: What Do Science, Technology, and Innovation Mean from Africa?

Clapperton Chakanetsa Mavhunga

Things do not (always) have the same meaning everywhere; when we insist that only "our" meaning is the "true" meaning, we silence other people's meanings. What passes as universality is someone else's culture and just enough power to spread it, even force it, upon others. The things that words denote never start as universal or available everywhere, their meanings already stabilized; they originate from a particular place, community, society, culture, and nation and then, through travel or mobility, become universal, global. The issue to address is why specific words get to be used when, how, and where they are.

Today, our definitions of *science*, *technology*, and *innovation* (STI) originate from countries and cultures that have acquired their dominance of others through global empires—military, capital, and media—and are able to purvey to or even impose upon those without such power their definitions. This asymmetry of definitional power was never lost to commentators in the West, like Edward H. Carr, who emphasized that people care to know and enquire into an event if it is worth knowing. If it is not, they forget about it (Carr 1961, 11). In that same discussion, Carr concluded: "When we take up a work of history, our first concern should be not with the facts which it contains but with the historian who wrote it" (22).

Similarly, in this volume the question is neither what the concepts of science, technology, and innovation mean universally or all the time nor what Western STI transferred or diffused to Africa means to Africans. Instead, we seek to put the concepts of STI up for grabs, on sale epistemologically, so that there is no universal or spatiotemporally transcendent definition. We seek to explore what the technological, the scientific, and the innovative might mean from Africa in lieu of outside introductions or influences. It is important to do this now because we feel that the importation and consumption of rigid Western meanings of STI are a serious and dangerous threat to a self-determined African path to the future.

The concepts of STI matter at this specific historical moment in Africa because there seems to be a feeling that Africa's time has come. This *Africa is rising* narrative is all over the World Wide Web, often under the name *Afrofuturism*. As if to capture its spirit, in 2014 the African Union issued a Science, Technology, and Innovation Strategy for Africa (STISA 2024), with science, technology, and innovation as the centerpiece of modernity. In the document, the

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three concepts are well-articulated according to their Western meanings but seem devoid of meaning coming from Africans themselves, barring a few well-educated elites. In this *Africa is rising* frenzy, there is a risk of uncritical discipleship, fed by corporate missionaries, driving the Africa conversation on STI.

But how does Africa come to STI, especially STI which is assumed as Western or transferred from outside into Africa? What should we make of modernity itself and its reduction to Western standards of measurement? What should we make of the reality that European modernity itself originated within the past five hundred years, a period of imperialism and its exploitative and colonizing tendencies (Mignolo 2011)? Are we certain that what we call "Western" science, technology, and innovation is indeed Western in origin, ingredients, and rationality? After all, from the Greek occupation of Dynastic Egypt of 323 BCE to the European colonization of the nineteenth century and now to this era of "big data," there has been a long history of translation and mobility of African, Asian, and Islamic knowledge and practices via the medium of colonial occupation and domination (Diop 1974; Mudimbe 1994). We should not be shocked that Europe's scientific revolution occurred after, not before, the colonization of the Americas and India. Through a global empire, Europe established a vast enterprise capable of reaching far-off lands and gathering the knowledges of other societies, bringing them home to Europe and America, and planting them in botanical gardens, zoos, and labs, subjecting them to biochemical analysis, which ushered in new drugs.

Given all that, Africans are coming to "Western" STI not as outsiders looking in but as coauthors of a knowledge store monopolized through imperialistic power. It is an empowering feeling: Imagine a positive Africa—creative, technological, and scientific in its own way. The problem is not with STI but how it is defined in alienation, such that Africans are made to enter as unsure and trembling visitors to other societies' achievements. That mindset is ahistorical, whereas the psychology of knowing that science, technology, and innovation are not Houdini acts of white people but the latest iteration of a long process of accumulative, multicultural knowledge production frees the mind to come to STI as a builder—past, present, and future. To that end, we must explore how the terms *science*, *technology*, and *innovation* have evolved into something so Western-centric, commercial, and artifactual to start with so as to put the chapters into context.

Science, Technology, and Innovation: The Origins of Concepts

In its rigid Western form, the language of *science* emerged in the nineteenth century. Since classical antiquity or the Greco-Roman period (500 BCE–500 CE), science was natural philosophy, with Aristotle and Thales as its key markers. The beginnings of the scientific method are from Europe's Middle Ages (400–1400 CE); two philosopher-scientists, the Arab and Muslim Ibn al-Haytham (Sabra 1996) and the Englishman and Franciscan Roger Bacon, were its flag bearers. The beginnings of contemporary scientific practice are pegged in Europe's scientific revolution (1400s–1800s) (Pingree 2005). Knowledge prior to that point is deemed

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"prescientific" and "false beliefs," whereas that after that point is thought of as "scientific," "modern," and "true theory" (Golinski 2001).

Thus, despite being systematic observations, pre-1400 methods (Chinese ones, for instance) are relegated to *prescience* because they were based on eyesight (visual observation) rather than laboratory or physical observation (Needham and Gwei-djen 1974, 1983; Needham, Ping-Yu, and Gwei-djen 1976; Needham, Gwei-djen, and Sivin, 1980; Hoffman 1998). What developed as means to fulfill and outcomes of mundane and spiritual needs—like dynastic (black) Egypt's architecture, astronomy, medicine, and mathematics (Homer 1998, 40)—is deemed *unscientific* (Lloyd 1970, 1979; Sambursky 1974). Thales, Aristotle, Plato, and other Greco-Roman natural philosophers are the "founding fathers" of science because they separated the natural from the spiritual. *Scientific method* became synonymous with the *antispiritual* or *secular*; credit went to a specific individual, not the entire society or school (Cornford 1971; Arieti 2005; Dicks 1970; O'Leary 1949).

Little has changed, as the debates of the last century involving Karl Popper, Ludwik Fleck, Robert Merton, Thomas Kuhn, David Bloor, and Paul Feyerabend illustrate. For Popper, *falsifiability* is the basic criterion for determining whether something is or is not science (Popper [1934] 1992, 102–103). That true or false measure follows Western scientific method and nothing else. Fleck had a more workable view of science as an outcome of not one but many "thought-collectives" and "thought-styles"—collective bodies that share a common culture (Fleck [1935] 1979, 35–47). However, his thought collectives were limited to experimental practice and expertise derived from formal training. For Kuhn (1962), science follows a cyclical pattern of normal science, crisis, revolution, and normal science again. Scientific communities, he said, conform to certain norms until a crisis challenges them, forcing the emergence of a new paradigm that resolves the crisis. Merton ([1942] 1973) defined *science* as "certifiable knowledge"—that is, statements of regularity that are empirically confirmable and logically consistent. In short, what made science scientific was its method—including disinterestedness, peer review, a reward system, competition, and intellectual property. For Bloor, science can only be examined within the social context of its production; the "natural" of science is not devoid of social content, nor is the laboratory a site of pure objectivity unpolluted by interests (Bloor [1976] 1991). Thus, Feyerabend rejects method as a marker for separating science and its others. Science, he says, is "one view among many and not ... the one and only road to truth and reality," and "the success of 'science' cannot be used as an argument for treating as yet unsolved problems in a standardized way" (Feyerabend 1975, viii, 2; also Ayer 1959, 14). Despite these protestations, Western scientific practice continues very much to be a privileged method, the source of all true knowledge.

The word *technology* comes from the Greek root *techne* (an art or craft) and *-ology* (a branch of learning). Nobody really asks: Where did the Greeks get that definition? Or: What did other civilizations, like the Egyptians for instance, call similarly denoted phenomena? Rather, the conversation moves too quickly to the term's first English translation, referring to the mechanic arts as a field, not an object. *Technology* only became a salient term at a specific

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moment in American history—the 1840s, when concepts like the *useful arts* and *mechanical discovery*, *improvements*, and *invention* became inadequate to describe steam power, electricity, the railroad, the telegraph, and myriad other new markers of "progress" (Bigelow 1829). Even in *Das Kapital*, Karl Marx consigned the word to a footnote urging "a critical history of technology" (Marx [1867] 1954, 406n2). The impetus for the concept drew from the so-called second industrial revolution of the Western world (1880–1910) and its products, like the electric light, the radio, the telephone, the X-ray, the airplane, the motion picture, and the automobile (L. Marx 2010).

This is how technology was reduced to a machine, invested "with the power to initiate change, as if it were capable of altering the course of events, of history itself." Respected American historian of technology Leo Marx's warning must concern Africa: "By treating these inanimate objects—machines—as causal agents, we divert attention from the human (especially socioeconomic and political) relations responsible for precipitating this social upheaval. Contemporary discourse, private and public, is filled with hackneyed vignettes of technologically activated social change— pithy accounts of 'the direction technology is taking us' or 'changing our lives'" (L. Marx 2010, 574).

The concept of technology has thus been weighed down by its privileging of economies of scale, a Cartesian and arbitrary view of what spaces must produce STI, and assumption of separation of powers between the producers (scientists and engineers in their built laboratory, as experts) and the consumers (society, as laypersons). We are made to believe that engineers design *for*, not *with*, society. A geophysical zoning of the definition and directionality of technology has been hammered into our brains: that technology is for academy-trained engineers, hence the emphasis on experts, and that technology can only come from the West and is "transferred" to the *technology-poor* Global South.

When Western technology travels, it is often cast in similar language. Historians of technology writing about the nineteenth century talk of products of the industrial revolution as "tools of empire" (Headrick 1981) and "tentacles of progress" (Headrick 1988) that enable Europe and America to exercise "power over peoples" (Headrick 2010). With better ships, Europeans could travel far; with quinine, they could stay alive while traveling; and with the telegraph and radio, they could communicate while on the move. Indeed, machines became the "measure of men" and "a spur to overseas expansion" (Adas 1989, 2; also Adas 2009). Yet as David Edgerton (2007) has cautioned in direct response to Headrick and Adas, the behavior of technology in the spaces of design and use "at home" does not always map readily onto foreign lands.

The task of doing STS in nonwestern contexts need not be one of simply tracing the mobility of Western artifacts and practitioners, situating them in the Global South, and commenting on their behavior in different environments, but taking seriously what technology means from the perspective of people of the South. It requires not merely looking at how people respond to incoming things, but placing the latter's arrival, meanings, knowledges, and materialities within the locals' technological *longue durée*. The arbitrary restriction of

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what constitutes technology to measurable things and experiments in the built laboratory performed only by those with mastery over them constitutes not just an epistemological exclusion, but also an ontological and sociological one (Shiva 1988; Stengers 2008). The propaganda around Western imperialism as civilizing mission was that Europe—and later America—alone had a monopoly of technology to "transfer" to a dark, primitive world. In the Global South, by contrast, both Western science and technology arrived and have lived their lives as tools of racist domination (Fanon 1970a, 1970b; Nandy 1988; Raj 2006; Anderson and Adams 2007).

A vast scholarship has focused on the systematic plunder of "native" plant knowledge to "feed the beast" of imperial technoscience (e.g., Shiva 1997 Osseo-Asare 2014). Another formidable body of literature investigates Western institutions experimenting in or bringing medical technologies to the South (Petryna 2009; Prasad 2014; Peterson 2014; Tilley 2011). Although these are powerful and much-needed explanations and critiques of the workings of Western technology, they still leave wide open opportunities for investigating the Indian or African as the central innovative agent driving or decisively affecting these incoming forces over a longer historical period. The people who have experienced colonialism, racism, and other forms of disadvantage generally come to discourse as the victim or subaltern of technology, inevitably because the chosen period of focus of these scholars (the twentieth century) was one of colonialism and apartheid or of its legacies (e.g., Shiva and the Research Foundation for Science Technology, and Ecology 2000; Moraña, Dussel, and Jáuregui 2008; Hecht 2012; Breckenridge 2014). Normally, when preferring to talk about the subaltern as a technological agent, scholarship focuses mostly on the strategic deployment of incoming ideas and artifacts as the so-called subaltern begins postcolonial self-reconstruction (Rajan 2006; Medina 2011; Prakash 1999; Abraham 1998). Always, the narrative starts from the colonial onward, ignoring that people of the South were already technological before colonialism happened. The language of STS generated from Western philosophical and empirical contexts is also exported and used to order Asian, African, and Latin American knowledge and practices, thus reducing local, non-Western registers to raw material for the scholars' own intellection.

Africa must be repositioned in technology as other than its pitiable victim. The younger generation—our children, our children's children—will require a positive African story to be inspired and to aspire. The narrative of victimhood alone will not be enough; the generation of our children, the African millennials, will want to see signposts of creativity—positive stories that will uplift them. As noted elsewhere, even where death is certain, situations insurmountable, people do not just roll over and die or raise arms of surrender. They die fighting (Mavhunga 2015). We have seen many stories of slavery, colonialism, apartheid, poverty, war, and disease associated with the black existence that can make any human being cry and want to "do something to help Africa." Can we not also write narratives that can inspire Africa to help itself, to do something about its own issues? Where are laughter, joy, happiness, creativity, means-making, and resilience in the African story? We have invested in

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showing how cruel others have been and forgotten how resilient, resourceful, and creative we have been in spite of it all.

The image of Africa in the technological imagination is still Hegelian; as scholars we feed and subsidize it by ending only with the trivial and the negative. Hegel himself ([1837] 2007, 99) described the continent as having "no movement or development to exhibit" and belonging to "the Unhistorical, Undeveloped Spirit still involved in the conditions of mere nature." In *Heart of Darkness*, Joseph Conrad captures well Western man's movement silhouetted against Africa's undeveloped spirit (Conrad 1902). Toward the end of the century, Hugh Trevor-Roper declared: "Perhaps in the future, there will be some African history to teach. But, at present there is none: there is only the history of the Europeans in Africa. The rest is darkness" (Philips 2006). Historian of technology Jack Goody (1971) singled out the absence of horse, plow, and wheel as a marker of Africa's technological inconsequence. For Walter Rodney (1972), the blame was elsewhere: in the export of Africa's human capital as slaves and its mineral and agricultural resources as industrial raw materials. Europe's technological development took place at the direct expense of Africa's. That led Marxist scholars to conclude that Africa was "preindustrial" before European colonization (Marks and Atmore 1980).

This is precisely the problem with simply importing concepts from outside to order intellectual discourse on science, technology, and innovation in Africa. This "imported magic" (Medina, da Costa Marques, and Holmes 2014) is not new. Since 1900, one could make out at least four turns or paradigms—most imposed either by Westerners or their colonial descendants, with Africans merely as "informants." The first turn (1910s–1930s) concerned two anthropological versions of functionalism, one emphasizing the psychology of "the native" (Malinowski 1922) and the other the structure of "native society," captured well in the work of Radcliffe-Brown (1952) and Claude Levi-Strauss ([1949] 1969). Whereas this paradigm was deployed to serve Europe's imperialist and colonial project, the second decisive, albeit structuralist, turn (1950s to 1980s) was in service of anti-imperialist and decolonial projects. Its applicators imported the writings of Karl Marx ([1867] 1954) and V. I. Lenin (1917) and repositioned the African historical experience as a class struggle, with Marx as a tool for analysis and political action (e.g., Nyerere 1962; Senghor 1964). The third turn was the cultural or poststructuralist turn, which imported and tested the ideas of Michel Foucault, Judith Butler, Jacques Derrida, Gilles Deleuze, Walter Benjamin, and others, well captured in the work of Ann Stoler and Fred Cooper (1997), V. Y. Mudimbe (1988), Jean Comaroff and John L. Comaroff (1991), and Achille Mbembe (2001). Meanwhile, a fourth paradigm shift, the environmental turn, was relocating the analytic from the social and cultural to the environment, borrowing its concepts from American environmental history. Its leading lights were William Beinart (Beinart and Coates 1995), Jane Carruthers (1995), Fairhead and Leach (1996), and Terence Ranger (1999), among others.

The fifth turn, to which this project contributes, is the science, technology, and innovation turn, dominated at present by self-identified STS scholars who deploy Western-derived concepts to order African empirical evidence. Because their priority is to follow Western-derived

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phenomena, and science, technology, and innovation as defined in Western societies, they do not devote energy to African meanings and practices to any significant temporal or nuanced extent. They do not necessarily intend to or have to, and we should appreciate what they bring to the conversation; their strengths positively help us understand the traveling Western artifact, idea, or expert. It is one optic we cannot do without, so that when we as black folk tell our stories, we better understand how the inbound forces that complicate our lives operate, from where they derive their motivations, and the ends to which resources extracted and freedoms and prosperities enjoyed at our expense are deployed. When meanings and practices of science, technology, and innovation derived from outside have become inextricable from who we are as Africans, we need explanatory allies, scholars who have dedicated immense energy and care to the workings of these inbound forces. The literature that has equipped us with this capacity to decode science, technology, and innovation in Africa is becoming quite impressive (e.g., Mitchell 2002; Storey 2008; Tilley 2011; Hecht 2012; Breckenridge 2014; Peterson 2014; Osseo-Asare 2014).

The point is not that the scholarship focusing on inbound things and versions of science, technology, and innovation is wrong; that way, we can constructively identify the shortfalls as opportunities for us to come into the conversation from a different optic. For a start, the scholarship mentioned earlier helps us understand the specific versions of (and traditions of thinking about) technology the scholars follow. The meticulous attention to these inbound versions of science, technology, and innovation leaves little, sometimes no room, for versions—let alone the very possibility of versions—that have local (pre- or non-European) origin. The inbound—besides that brought by European colonizers—was coming from sites of production marked by exclusions on the basis of race and gender. It was mostly produced by white males; and it was coming to make wealth, power, and prestige for them in Africa. It is not enough, however, to have an account of how these white technologies, this white science, unfolded in the hands of white agents at the expense of black victims. For those versions to speak to Africans as intellectual agents and as thinkers, creators, and doers of technology, a deep immersion in Africa's idioms and long histories is required, with its own vernacular registers and syntaxes that are only partially found in writing. Few scholars are ready yet to be both thoroughly immersed in STS idioms and empirical material on one hand and those emerging out of Africa on the other. In any case, most STS scholars are trained in methods that enable them to work within only colonial and postcolonial history and anthropology; it requires a vaster repertoire to undertake an intellectual history of technology.

Africa clearly needs histories and philosophies of technology, but which ones? Although there is now a large body of social science and humanities literature on technology design and use relating to the Global North, Africa is made conspicuous by its absence from the discussion. When it is included, it comes into the story only as a recipient of technology transfer from the North or as a victim of (Western and colonial) technology or its appropriators. That, or Africans, are portrayed as just *tinkering* (that horrible word!) and responding without initiative or inventing anything. *Tinkering* is such a horrible word because it refers to

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a mender of what is already made, a trial and error person, a meddler, or, worse yet, a clumsy, unskilled worker. The chapters that follow seek to go well beyond that lazy narrative to propose people deeply engaged in intellection, firmly anchored in their own philosophies, and alert to the world around and beyond them as a source of things that they render technological.

The reduction of innovation to technological and commercial ventures—and technology to iconic objects and processes—is a recent interpretation of phenomena that used to embrace much wider historical, cultural, environmental, and political systems (L. Marx 2010; Godin 2014). Three elements are at the core of Western innovation today: novelty, invention, and making money. Until the mid-eighteenth century, imitation was positively viewed as selective borrowing and creative copying that substituted for imported goods and lowered costs of original products (Godin 2008a, 7–10). During Europe's renaissance, imitation was invention (Wittkower 1965; Hathaway 1989). By 1750, originality had become invention, imitation mere copying.

Invention itself has a long history in Western society. It emerged out of the classical rhetorical arts as a guideline for the fine arts. By 1350, it referred to the discovery of knowledge or knowing, and two centuries later, it referred to makers and their artifacts. Hence, in the sixteenth and seventeenth centuries, invention was a *venatio* (hunt or search) for knowledge (Eamon 1994; Hadot 2004). From the seventeenth century onwards, with patent laws and the West's consumer and industrial revolutions, invention referred to technology and luxuries. With the rise of the research laboratory, invention was conflated with machines, artifacts, devices, engines, and methods for "the relief of the human condition" (Francis Bacon, cited in Zagorin 2001, 390).

The term *innovation* itself emerged out of *novation*, a thirteenth-century legal term referring to the process of redrafting a contract to renew a debtor's obligations. We love to be called *innovators* today, but until the nineteenth century a *novator* was a very distrusted person (Godin 2008a, 21–22). With the advent of the patents regime, imitation became theft (Macleod 1988; Hilaire-Pérez 2000). The technologization of innovation began in the 1860s, with economists increasingly seeing technology as a cause of economic growth, a spur to industrialization, social change, crisis, and revolution. Thus, from the 1920s to the 1930s, technology was seen as labor and capital saving and a sign of measurable efficiency; productivity became an indicator of technology usage (Stern 1927, 1937; Gilfillan 1935; Ogburn 1941, 1950).

The decoupling of innovation from invention and its attachment to technology gathered momentum in the 1930s and is often credited to Joseph Schumpeter, especially via his now famous statement: "Innovation is possible without anything we should identify as invention and invention does not necessarily induce innovation" (Schumpeter 1939, 84). However, as Godin (2008b) has decisively argued, the Austrian-American economist and political scientist's notion of *technological innovation* was feeding off the literature of the 1920s to the 1930s. The concept is owed instead to Rupert Maclaurin (see 1949, 1953), who

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increasingly pinned technological innovation to commercialized innovation. His writings posited that technological innovation starts in basic research, goes to applied research, then development, then production, and then diffusion (marketing, supply, distribution; Godin 2008b). Productivity becomes the measure of progress, technology the means to achieve it. Economy is summarized to *growth*, not *sustainability*; as resources dwindle, a postindustrial society beckons (Toffler 1970; Bell 1973; Gosh 2009, 2012, 2015).

The science policy model that emerged in the post-1945 period was a Maclaurinian one (Godin 2008a, 36) and illustrates the synergistic roles between theorists, research institutions, and governments. The most influential theorists of innovation have also been consultants for or employees of governments. They have advanced policies based on their theories, like "the knowledge-based economy," "the information economy," "the new economy," and "national systems of innovation" (Godin 2009). Examples include researchers from the RAND Corporation in the United States (Hounshell 2000), the Science Policy Research Unit at Sussex, and Maastricht Economic Research Institute on Innovation and Technology (MERIT) in the Netherlands. Their models have been exported as templates to other countries through manuals, IMF and World Bank structural adjustment policies (SAPs), and bilateral trade agreements (Godin 2005). To cite one example, under the R&D-centric approach, two-thirds of R&D expenditures are devoted to the development of new technologies (Godin 2006). The Organization for Economic Cooperation and Development (OECD)'s methodological manual for measuring innovation, the Oslo Manual (OECD, 1991), as defined in the US Department of Commerce's Charpie Report, is a perfect example of this technological and commercial reductionism in the concept of innovation (Godin 2008a).

Can Africa follow these models of STI given its specific conditions? When 80 percent of the budget of countries like Zimbabwe goes to civil service salaries? When the bigger share of Africa's budget relies on IMF and World Bank balance of payments support? When countries thus have meager funds to invest in R&D and yet make it the centerpiece of their STI policies anyway? When since slavery the West has used Africa as a mere source of raw materials (including cheap labor) for its development, a market for its finished goods, and a dumping ground for its disused products? Moreover, how exactly does Africa trust STI advice from the same experts that have devised systems of innovation that relegate Africa to a receiver of Western-produced R&D and a source of unprocessed natural resources and agricultural products for the West and East's industries?

African Science, Technology, Innovation, and Entrepreneurship: Snapshots

This book locates Africans between their locally generated and inbound ideas, instruments, and practices. It places these two, endogenous and inbound, within cultures in which bench science was not the norm of knowledge production and bench science itself was an inbound system of inventing and for which local practice has not contributed too much to changing the lives of ordinary people. Bench science—especially R&D—remains an elitist,

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university-centered practice, something taught in class in primary and secondary school and usually left there. It doesn't come home—to the village, to the streets. The dilemma of knowledge production in Africa centers on how its structures, practices, and concepts came to be informalized while inbound European ones were rendered formal. This was particularly the case with metalworking, pottery, beer brewing, agriculture, trade caravans, and hunting, for which modes of knowledge and knowing (science), ways and means (technology), and innovation (creativity, experimentation, and strategic deployments) are already well-known. These pursuits are sketched in figure 0.1.

From the time that humans began making tools in stone, bone, and wood, Africa has hosted different forms of *nzvimboshandwa* (workshop or, as the French encapsulate, atelier). There were no spaces singly designated for science, technology, or innovation; in fact, one cannot separate one from the other. In *Transient Workspaces* (2014), I called them *schools* and showed how African children were educated within them through doing, through being *vadzidzi* (apprentices). Hence the hunt was a professoriate of forest knowledge; the ironsmith's blast furnace, the potter's workshop, and the weaver's loom were Africa's

Figure 0.1
Some sites where science, technology, innovation, and entrepreneurship have been practiced in Africa, from the earliest times to the present.
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apprenticeship and engineering schools or innovation/tech hubs, while the trade caravan and marketplace was and remains the African business school par excellence.

Research on longstanding trade practices and routes has exposed African innovations in marketing, transport, currency systems, and commodity exchange. Some of these narratives suggest that the idea of an *entrepreneur*—defined as a person who starts a business and is willing to risk loss in order to make money—is sometimes morally repugnant and ethically fraught in the African context. For example, how should we address entrepreneurship involving the hunting, capture, and force-marching of African men, women, and children as commodities, bound in shackles and talons, to the waiting slave ship and, on the other side of the Atlantic, turning them into Europe's—and America's—first machine of mass production on the plantation? This is the case of the *ogaranya* (wealthy men) among the Igbo of West Africa, not only prior to the abolition of the trade in Africans as slaves in 1807, but right into the second decade of the twentieth century—*ogaranya*, for example, men like Chief Igwebe Odum (Njoku 2008, 27–33). Mandinka *jula* (merchants), often celebrated for their risk-taking and overwhelming success, traded extensively in enslaved Africans at the Fatatenda and Wuli markets (Wright 1977). Throughout Africa, the practice of sacrificing the enslaved, kin, strangers, and their body parts to make a business thrive is well-known; there has existed the perception that sound business principles are not enough to stabilize and scale up a business. Colonialism was itself a start-up project in most countries: some ambitious individual obtained fraudulent concessions from African rulers; formed a company to exploit the concession; obtained a charter from the British, French, Portuguese, German, or Belgian government to occupy the land to safeguard its investment; and raised money on the European stock exchanges to undertake colonization, with the goal of paying the investment back by exploiting the land and its people (Agiri 1977, 3).

As repugnant as all these examples are, we should also note the trade practices and education for children of merchants to become merchants. It offers us a space from which to radically rethink the ideas of hubs, startups, and platforms that is now associated with the narrative of "how mobile technology is changing Africa." Indeed, this long history of integrated production-transportation-marketing systems with information management and communication at its core is an invitation to think of science, technology (even engineering), innovation, and entrepreneurship more organically and over a long time frame.

Take the example of the trans-Saharan trade routes, the history of which stretches across millennia. The oasis was a marketplace, an important juncture and resting depot for traders. Commodities were transported on the desert highway by camels, all the caravans and routes passing by oases. Commoners were forbidden from participating personally in foreign trade, and rulers taxed all export commodities (Kapteijns and Spaulding 1982, 30). The reason for paying the tax was simple: "In whose country, by which road could one have traded?" Gifts were exchanged between rulers of lands along which trade routes passed and in which essential commodities were produced. This was done to secure the macroeconomic environment for entrepreneurship. Hence, as Kapteijns and Spaulding (1982, 32) have noted,

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"Reciprocity gifts were the language of diplomacy and expressed both the nuances and fluctuations of political relations between the states." Private traders were attached to the royal caravan and received protection, guides, and royally sponsored interstate exchange facilities—for a fee, of course. Foreign traders' first port of call was the king's court or the household compounds of the big traders, with enslaved people usually sold privately (La Rue 1984, 60). Where marketplaces did exist, the forest paths functioned frequently if not primarily as trading lanes linking together different regions and peoples (Handwerker 1980, 3). Bear in mind, however, that markets were not simply fixed places but mobile or itinerant—what I call *transient workspaces*—that depended entirely on reliable market information passed through merchants moving between source and market (Dalton 1978, 134).

The trans-Saharan trade route is a perfect example of a transient workspace in which the training and apprenticing of children occurred via doing and showing. This is hardly unique; in *Transient Workspaces* (2014) I gave the example of the hunt as a professoriate. Even today, African entrepreneurial training is on-the-job apprenticeship; it constitutes the bulk of expertise that drives the informal sector. In precolonial Sudan, for instance, an entire clan was composed of merchants. They exposed boys to mercantilism early in life—in hospitality, bargaining, desert-crossing survival skills, and caravan guiding—under an uncle or father, for example, among Darfu caravans (La Rue 1984, 62). In Arochukwu society (Nigeria), trading was a form of education, and children learned buying and selling processes early. A boy usually started with trade in lizards (*mgbere ngwere*) under his master, a successful merchant; by the age of ten, he began trading in tortoises (*mbe*), considered a higher commodity than lizards; by age thirteen, he graduated into trade in towels (*ákwá-mmiri*); by age sixteen, he participated as a warrior in local wars; at twenty-two, he entered training as a slave dealer (Njoku 2008, 35).

The tech talk about Africa today is populated with phrases like *start-up* and *financing*. Among the Mandinka of West Africa, two types of strangers coming into a *jula* community offer intriguing insight into start-ups long before 1500 and prior to European colonization. One was the *suruga*, a person who would come to a new village without means, submit to the care of a generous host through whom he became kin, gain access to trade on the host's good name and account, and eventually marry within the family (Wright 1977, 35). Compare the *suruga* to the *samalan*, a much more independent chap who provided for himself, paid a fee for land use, did his own work, and paid his way through everything, including marrying locally and becoming *jula*.

In earlier times, Tuareg herders of the central Saharan oasis of Kawar exported thousands of tons of salt dug from salt pits a year. Theirs was the hub of an economic system consisting of a large area astride the desert and its southern periphery from 1700 until French colonial conquest in 1906. They were not capitalists but clansmen, with a system for regulating salt production. The salt pit was a site of technological innovation and knowledge process, as seen from salt-production techniques (evaporation of subsoil water), digging and extraction, equipment, and modes of commodity exchange on site (silent trade); hence, this could be

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called an *integrated platform* combining production and selling. The two parties to the transaction (the producer/seller and the buyer) never came into contact with one another. One came, left a commodity, and returned to his position a short distance away. The other came, inspected the goods, and left what he considered fair exchange beside it, and disappeared. The first party returned and inspected the exchange. If he accepted it, he took the proffered goods with him, and the deal was done (Vikør 1982, 125). Every salt basin produced its own unique product, and each salt basin owner therefore labeled his own salt differently to enhance competitive advantage. To develop the pit, each had to secure credit lines from wealthier kin or the chief.

In general, European colonialism from 1885 to the late twentieth century killed, disrupted, or delegitimized these sites of innovation and entrepreneurship by displacing Africans from their lands, creating farms and game reserves out of them, subjecting them to forced or miserly paid labor, and forcing Africans into cash crop production. The example of early colonial southern Dahomey, a region that includes peoples of the Aja-Ewe and Yoruba groups, shows the danger of imports killing local modes of innovation. Before inbound goods, specialists performed spinning, weaving, tanning, dyeing, pottery, woodwork, calabash making, and salt making work, but in many cases cheap, less arduous imports supplanted these vibrant yet strenuous activities that demanded more labor for less output. The competition from imported salt, carried as far north as the Niger, caused abandonment of salt manufacture in many places. Sewing machines replaced hand sewing (Manning 1980). Kola nut, domesticated and grown among the Yoruba, became the critical ingredient in Coca Cola, but in addition from 1901 the British Administration urged the introduction of the crop into parts of Northern Nigeria to which the Yoruba had not already spread the crop to before the colonial partition (Agiri 1977, 4).

Rubber is another perfect example of the morally reprehensible aspects of capitalist entrepreneurship as imperialism. Abir, the largest rubber concession company in the Congo Free State founded with Belgian and British capital, created no long-lasting entrepreneurial structures, introduced no new technology, no new market relations, no new indigenous elite—it was just like King Leopold II: "a plundering and tribute-collecting empire of the crudest sort" (Harms 1983, 125). The Belgian monarch had colonized Congo as his personal property. With the colonial subjugation of the area complete in 1898, a brutal regime of forced rubber collection began. Men who did not bring in enough rubber were often imprisoned and put to work drying rubber, but because a man in prison was two rubber-collecting hands lost, some Abir agents took hostages instead, holding a man's wife or close kin until he completed his quota, or thoroughly flogging someone with the *chicotte* (hippo-hide whip), or imprisoning the chief of any village that fell behind in his rubber deliveries. Others tied people to platforms facing the sun, burned them with gum copal, or simply cut off their ears, noses, and hands and mutilated their faces (Harms 1983, 134).

The last example of European entrepreneurship severely disadvantaging Africans is that of cotton, and here the story becomes a complex one of brutal colonial practice and Africans' creative resilience in the face of it—that is, innovation in the face of virtually

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insurmountable odds. People in different parts of Africa had grown or used wild cotton for clothing and other purposes before European colonization. The colonial authorities compelled Africans to grow cotton as a cash crop on a large scale. From 1911, the French in Chad, for example, forced Africans to grow cotton under supervision of their chiefs, who were stripped of their rank and turned into forced labor themselves if they refused. The authorities sent out local clerks—*boys-cotons*—to prescribe what and how much land to be set aside for cotton. The program was a staggering failure (Sturzinger 1983, 217). Initial attempts to execute a similar system in Mozambique had also come to nothing, prompting colonial power Portugal to issue a decree giving extensive power to concessionary companies to compel Africans to cultivate cotton. The decree still failed, despite putting eighty thousand Africans under forced labor. In 1938, Lisbon authorized that the full force of the state be placed at the disposal of the Cotton Board to squeeze more production out of Africans. The work day was extended, mandatory cultivation mercilessly enforced, and vast regions decreed "cotton zones." The colonial administrators made regular inspections, chiefs harassed and threatened their own people, and those caught fleeing were publicly flogged or often sent to jail (Isaacman 1985).

Creative resilience is best illustrated in the story of cotton in Uganda, which also exposes the parasitic nature of the colonial state as a capitalist entrepreneur or enterprise. It is the story of Africans already growing cotton and then proposing to scale it up into a cash crop to be able to pay taxes and avoid punishment from British colonizers. The key figure was Samwiri Mukasa, a Muganda chief from 1897 to 1926, who approached the agent of the Uganda Company, Kristen Borup, with a proposal to turn cotton into a cash crop. Borup agreed, provided that Mukasa pay a surety in case his people refused to grow the crop. Mukasa pledged twenty square miles of land and 1,200 rupees as security and enthusiastically distributed cotton seeds. Thus began the Bulemezi cotton venture, which spread to other parts of Uganda. It is also how Chief Mukasa earned the name *Muleta Pamba* or introducer of cotton (Nayenga 1981).

Located on the Kenyan coastline, Lamu challenges the frequent argument that Europeans were able to conquer and govern because of their superior science and technology. By the first decades of the twentieth century, mangrove poles brought scores of dhows (locally made sail ships) southward each year from Arabia, Persia, and Somalia. Coastal people regarded mangroves as a resource free for the taking by anyone with the need or ambition to do so. In 1907, the new British colonial government stepped in; it declared all mangrove swamps crown land and granted concessions to private companies like Smith, Mackenzie & Co. and then to Indian merchants like Mulla Taibali, whom it taxed. Still, as Philip Curtin shows, the real entrepreneur was neither the colonial government nor the concessionaire but the foreign captains of the *jahazi* (dhows), who paid the private concessionaires for a specific number of poles to cut and hired local Africans to cut them and transport them to ocean-going vessels. This grassroots process was exceedingly difficult to supervise, and dhow captains simply bribed the right people and paid for just half the poles loaded, with one-third of

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proceeds going to the owner of the boat and the rest to the crew. The *jahazi* captain depended on buyers based in Lamu, who stockpiled the poles until the bigger dhows arrived with the monsoons from Arabia, Persia, and Somalia (Curtin 1981). In essence, the knowledge and methods used to harvest mangrove poles was endogenous and a continuation of non-European practice: a kind of technological version of indirect rule wherein the colonizer, severely outnumbered by Africans, extracted resources through local idioms.

KwaZulu-Natal provides a different dimension and directionality of knowledge: of Africans and inbound things that they reassigned technological purpose. From 1845 to 1880, a period of increasing Euro-African contact in South Africa, Zulu *kolwa* (those who had converted to Christianity) partook of a series of initiatives representing one of the most successful integrations of inbound things to come out of Southern Africa. They turned the Christian mission into a platform upon which Africans staged many experiments, especially those of innovation and entrepreneurship. Congregational, Methodist, and Anglican converts had acquired "mission reserves" from the colonial administrator, and in these reserves, *kolwa* were allocated land. They took well to European tastes, adopting European clothing, looms and needles, sewing machines, and brick houses with iron roofs.

Contrary to the statements of scholars like Norman Etherington (1978, 1), the missionaries were not "prodding" these Zulu toward "progress"; the Zulu had dreams of their own and took bold risks to realize them. They were not just *kolwa* but Africans who came and located themselves at sites where better opportunities to acquire tools for realizing their futures existed. At a mission station called Mvoti, for example, one missionary in 1864 counted some forty-eight upright houses, twenty-two ploughs, fourteen wagons, and twenty spans of oxen. One Methodist minister, Daniel Msimang, owned two houses on an eighty-nine-acre plot at Edendale, plus the following moveable property: two ploughs, two wagons, thirty-six oxen, 260 goats, and twenty cows. Cattle were not *means* to wealth; they *were* wealth. Ploughs, oxen, and land were utilized to produce crops, oxen and wagons as transport for trading expeditions. Msimang's community included thirteen farmers, eight men employed in teaching or ministering, six in transport or trade, ten skilled artisans, and three unskilled laborers. All their activities were profit-driven: growing cash crops like cotton (1847), sugar (1860), and manufacturing sugar.

This remark by one surprised missionary puts things in perspective:

> Men with black skins who a few years ago were naked boys ... are now competing with the white man in manufacturing sugar in a steam mill of their own from canes of their own cultivation and without any superintendence in the work; the men have incurred rather heavy money liability in erecting the mill (about six hundred pounds) but I see no reason why with ordinary success they may not hope to clear themselves in a comparatively short space of time. (cited in Etherington 1978, 3)

However, the land upon which the Africans grew and processed sugar cane was inside the Locations and Mission Reserves, where freehold tenure did not exist, and magistrates refused to allow blacks to buy land elsewhere, and government did not provide credit lines to blacks.

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By 1881, these Zulu entrepreneurs had become "afraid of sugar growing, because it takes so much capital" (Etherington 1978, 4).

The second type of entrepreneurship in this prerailway age was ox wagon transport. Zulu men had been raised and trained in cattle handling, and ox wagon transport was in high demand. Every driver dreamed of owning his own wagon and trading independently. As one American missionary noted:

> You will find them with bundles of the skins of the wild cat or monkey, or blankets which they have probably purchased on credit, traveling through the length and breadth of this country and even those bordering it, bartering for hides, goats, sheep, young cattle, and then selling these to each other or to the white people. After a few years some will succeed in obtaining a few oxen and a cart or wagon, when they will engage in purchasing mealies and take to the towns for sale, or will draw sugar from the sugar estates to market, or perhaps transport merchandise from the Port to the upper districts, going sometimes as far as to the Dutch Republics or even to the Diamond fields or Goldfields five hundred miles distant. (cited in Etherington 1978, 6)

By 1850, Kolwa trading had begun spreading from the Natal settlements into the rest of KwaZulu, and by 1870 it extended into much of tsetse-free Southern Africa, the furthest extent oxen could pull wagons without succumbing to the insect's deadly bite.

The Zulu example is only a snapshot of trends set with the coming of Europeans, colonialism, and its legacies, which concentrated and specialized goods and services around specific nodes—namely, stores (urban factory-produced groceries, etc.); marketplaces (trading in goods produced in informalized activities); stock exchanges (formal sector trading); industrial sites/factories (European-originated methods and instruments of production; formal goods); farms and mines (owned by Europeans or whites and Western multinational corporations); and "native" reserves or communal lands (the majority of the people).

The interlocked narrative of innovation and entrepreneurship and the Euro-African encounter must also consider fully the role of Indian, Lebanese, and Jewish entrepreneurship in Africa. The Indian entrepreneurial presence in particular has been closely associated with both collaboration with and resistance movements against colonialism—in South Africa, Zimbabwe, Mozambique, Tanzania, Uganda, and Kenya in particular. Indians in Africa have always drawn their power from entrepreneurship, going into places where no other foreigners want to go, setting up shop in remote localities where few to no other businesses exist, buying out the competition and establishing a monopoly. Their unequalled gift is persuasion and bargaining: in Zimbabwe, we call them *buya tinapangana* (come, let's talk); fixed price means nothing to them. Their competitive advantage lies in being the cheapest, sourcing cheap, and moving stock off the inventory quickly. They locate their home either in the backyard or upstairs, get as many of their kin from India as possible, and often keep their money with them. This is exactly what they did in the British colony of Uganda in the early twentieth century, specifically in the kingdom of Busoga, where they settled at the homes of traditional chiefs, bought local produce, and sold locals goods from their stores. They became

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middlemen, buying African-grown cotton cheaply and marketing it to ginners at exorbitant prices, and not before long they established their own ginneries. This is the story of two tycoons, Nanjibhai K. Mehta and Muljibhai P. Madvani, two men who bargained down the farmers whom *Muleta Pamba* had inspired into pioneering commercial cotton production in Uganda (Nayenga 1981, 189). Just two ginneries out of the eleven in 1920s Busoga were European-owned—testimony to the Indians' monopoly model, which I also observed in Limpopo province, South Africa, and grew up with in Zimbabwe—the Gulabs in Marondera, the Patels in Harare, and Narans of Bulawayo.

The final snapshot comes from the post-independence period leading to the present. Most African countries either adopted socialist-based policies or a pragmatic blend of socialism and capitalism to address economic growth/modernization and social welfare programs. In socialist countries, government controls either stymied or completely eliminated "individualistic" or "capitalistic" business, with countries nationalizing multinational companies, specifically in Mozambique. In others, like Zimbabwe, governments nationalized some big corporations into or maintained existing parastatals (state-owned companies), established black economic empowerment programs to create an indigenous entrepreneurial class, and actively promoted both cooperatives and private entrepreneurship. These government subsidy–heavy programs put a drain on budgets, and soon countries were knocking on the doors of the International Monetary Fund (IMF) and the World Bank. With this move came deregulation, economic liberalization, removal of socialist subsidies, and denationalization.

The consequence was that governments were compelled to pull out of business. I was in high school when the Zimbabwean government succumbed to the Bretton Woods institutions' "bitter medicine" in 1990. I was at the University of Zimbabwe when its many biting consequences began setting in. We began to see parastatals that had run quite well, like the Dairy Marketing Board (DMB), the Cold Storage Commission, and Ziscosteel, becoming privatized. As students we took to the street weekly in 1993 to protest (unsuccessfully) the privatization of accommodation, food catering, and student tuition and living allowance (payout). We unsuccessfully tried through protests to convince the government that deregulation—which now turns out to have been pushed by the Republicans during the George H. W. Bush era—would result in the dumping of cheap imports and kill local industry. At the time, David Whitehead, Cone Textiles, and Darryn Textiles were thriving. By the time the IMF was finished, each one had shut down, swamped by cheap, secondhand clothing. The IMF also insisted on cutting the budgets of the government and companies, especially relegating the role of the state to facilitator, not active investor or entrepreneur, ending a tradition of state involvement in business dating back to long before and during the colonial moment. Companies that had relied on subsidies to continue producing goods deemed to be in the national interest and to sustain the trade balance were ruthlessly exposed. By 1997, thousands of workers had been laid off as part of the "rationalization" programs of the IMF.

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Rationalization is a term that assumes that prior to the IMF and World Bank interventions, African countries that adopted such structural adjustment programs (SAPs) had been behaving irrationally. Yet countries like Zimbabwe achieved significant milestones during the pragmatic socialism phase of their postindependence moment. Zimbabwe leapt forward to become the country with the most literate population in Africa by the end of the 1990s and has hovered either at the top or thereabout since. That would have been impossible without free primary and secondary education and a vigorous payout and student loan system at universities. It was also an accomplishment based on a philosophy of African socialism, firmly rooted in communality, which mobilized rural communities to mold clay bricks, fire them, and cart them to school in lieu of school fees to build then nonexistent schools. I vividly recall molding these bricks to build the block that sits near the plantations at Chitangazuva Primary School, firing them, and, in typical African innovation school style, apprenticing in the arts of molding, placing the bricks on *hovhoni*/oven or kiln, loading the logs into the openings, sealing the walls of the kiln, pouring sand on top, then firing. These are the bricks that enabled us and our parents to meet government contributions—solicited from donors, mostly the Nordic countries that had fought with the then-guerrilla movement now turned government—halfway.

Zimbabwe also developed perhaps Africa's best postindependence healthcare system based on free primary healthcare—something which even the United States of America has never made available. It also embarked on "food-for-work" programs (which the elderly transliterated as *futuweki*), whereby whole villages were mobilized to provide labor for rehabilitating sand- and silt-clogged rivers and nasty dongas and to plant gum trees to serve as windbreaks in open grassland areas like Chihota in exchange for drought relief food. There was nothing "irrational" about these programs to require "rationalization."

Finally, through its Grain Marketing Board (GMB), the government vigorously introduced an agricultural inputs scheme, whereby our parents would get deliveries of fertilizer and seed for the upcoming season on time. This program built on the industry of ordinary people, with children working in the fields with their parents, learning through doing, and utilizing the considerable family sizes of the black majority as the basic unit of mass production. The grain was sold to the GMB, which deducted its fertilizer and seed input costs and gave the farmers the rest. This inputs scheme also ended with IMF intervention. Food security in Zimbabwe was already threatened by the time the government embarked on its land-reform program.

The second part of this postcolonial snapshot relates to the contemporary period of information and communication technology (ICT)-based platforms, characterized by *imitation* (importing or transferring models that have worked well elsewhere and implementing them in Africa) and by the creation of synergies between inbound and locally invented modes of innovation and entrepreneurship. It is often overlooked that Africans—specifically the Rwandan entrepreneur-engineer Miko Rwayitare and his Telecel company—are the ones who first introduced the cell phone and subsequently mobile technology to Africa in 1986. Until

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then, Africa had relied on fixed telecommunications first laid out in the colonial period for voice communication and on letters and telegraph for textual communication. Mobile also relied on satellite to transmit. As I see it, ICT is just a platform, a stage on which Africans are setting themselves up to create innovations. They are strategically deploying *things* (the mobile phone, computer, and Internet) to effect their dreams. Credit often unfairly goes to the gadget, as in *see how mobile technology is changing Africa*. Wrong! We should instead see *how Africans are changing mobile technology*. Ahead, I will discuss only examples in which Africans are changing this technology in a way that integrates the inbound and the locally generated as raw materials for creating something entirely new.

Although Rwayitare pioneered mobile telecommunications infrastructure, continent-wise, credit for digital mobile technology is owed to the political and strategic vision of the main protagonists behind Africa hosting the 2010 World Cup tournament. The most important figure was Thabo Mbeki, then South African president, with not-insignificant help from the persona and charm of Nelson Mandela. I was in Johannesburg when the news broke. The argument I heard Mbeki articulate on radio and television was that the World Cup event should be awarded to South Africa—the tip of the continent—so that the undersea cables could go round the furthest part of the continent and thus circumnavigate the entire continent. If the event was awarded to Egypt—the other bidder—the moment would be lost for good, because the rationale for such infrastructure development was to televise the games digitally in Europe and the Americas. The subsequent event led to laying undersea cables near Africa's shores, linking them with the Europe to India cables to connect the East Coast, and stretching from the West Coast to Brazil to link with Latin America and, by extension, North America. Often, we are caught up in the technical and financial aspects of the undertaking, completely ignoring the strategic deployment of the World Cup to obtain cyber infrastructure: the credit for Africa hosting the World Cup goes to Mbeki.

The effects of the new infrastructure were quite rapid. Two years after the World Cup, there were twenty-one innovation or tech hubs around the continent—spaces where research and development, entrepreneurship, and marketing that is heavily reliant on leveraging mobile technologies takes place. By September 2015, the figure had risen over five times to 117—and counting. Some of these hubs were created in 2010. Most of the bigger ones are concentrated in the cities of Tanzania, Ghana, Kenya, and Zambia and serve as incubators for start-ups. Perhaps the most ambitious of all is Botswana's first science and technology park, called Botswana Innovation Hub (BIH), an example of an integrated platform for scientific, technological, and indigenous knowledge-based innovation. BIH has five sectors: clean tech, ICT and ICT-enabled services, mining tech, biotech, and indigenous knowledge. BIH's biotech node explicitly seeks to undertake R&D and entrepreneurship in the testing and manufacture of indigenous natural products. The indigenous knowledge systems (IKS) sector focuses on local-level decision-making and cultural activities of rural communities. IKS has value not only for the culture in which it evolves, but also for scientists and planners striving to improve conditions in rural localities.

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A second feature of the post-2010 era is the development of ICT- or app-based platforms that serve as spaces for conducting transactions. Here are a few examples. One is a multimedia platform for music streaming, which has opened up possibilities for African artists to reach new audiences, especially with the development of the smartphone. Among some of the most successful ones are Simfy Africa (South Africa); Spinlet, iRoking, Vuga, Orin, and Las Gidi Tunes (Nigeria); Mziiki and Mkito (Tanzania); and the Kenyan outfit Mdundo (Kenya) (figure 0.2). Their music inventory includes Afrobeat, gospel, dancehall, Fuji, highlife, hip-hop, hiplife, house, Júju, Kwaito, reggae, R & B, and traditional genres. Many artists have over four hundred thousand subscribers. Spinlet, for example, invites such artists to upload music to the site and earn 90 percent of the revenue generated, with the company getting 10 percent. The payout per stream is currently about US$0.038.

The second example is the social network app. Outside of Whatsapp, Twitter, Facebook, and LinkedIn, Africans are developing their own social networks. Most of them are still country-specific—for example, MXit in South Africa—or limited to certain countries or just the diaspora; a few are continent-wide and connect Africa and its diaspora, such as Africanzone and Yookos, the latter starting out as a Christ Embassy International platform before broadening. Some African Pentecostal churches use their church names—for example, the Kimbanguists in Congo and Tomitope Joshua's Emmanuel TV. They speak to the power of spirituality driving ICTs in Africa, which shows the marshalling of forms of social kinship

Figure 0.2
Music streaming platforms in Africa as of 2016.
Source: Author.

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into a sustainable base of customers. Increasingly, villages and communities—platforms in their own way—are entering online platforms so that scattered members in the diaspora and the city can network. Some of this activity occurs on Facebook and Skype, but it is Whatsapp that has really driven this movement, at least in my village.

The most inspirational and urgently needed innovations derive from people who respect and thoroughly understand local modes of knowledge and build upon them. They are not just looking at the local as a problem that tech (i.e., the inbound) can solve but as a source of technologies that they can synergize with incoming materials to unleash opportunity from what people are already doing. Good examples of such synergy include eSoko, Rural eMarket, M-Shamba, iCow, and Hello Tractor. eSoko is an information and communication service for agricultural markets in Africa built by local developers and consulting staff in Accra, Ghana, as an ICT-response to preexisting and thriving farming; it offers services like market prices, weather forecasts, and growing tips and business strategies relating to product marketing, market monitoring, supplying, and sourcing. It also includes automatic and personalized SMS alerts, buy and sell offers, bulk SMS messaging, SMS polling, Android (operating system) surveys, and more. eSoko is the "e" in "electronic" affixed to Soko, kiSwahili for Market. Today, eSoko can be used anywhere with any mobile phone and is in use in Ghana, Kenya, Burkina Faso, Nigeria, Malawi, Zimbabwe, Benin, Madagascar, and Mozambique. iCow is a platform for dairy agricultural products lined up on a menu, the brainchild of a team of young Kenyan techpreneurs led by Su Kahumbu and Charles Kithika. It helps farmers to manage their cattle. What I found so impressive is that Su Kahumba is a woman who grew up on a farm and is using that knowledge not just to find a problem to be solved by ICT but as a rich knowledge base to add value to mobile phones and their possibilities. Rural eMarket is a multilingual app to affordably communicate commodity info about and enhance rural access to markets, including and especially in communities in which people didn't go to or didn't get far in school. It was developed in Madagascar in recognition of access to market being one of the biggest blockages for development—that is, the need to find the market and the right price for a product. M-Shamba is an interactive platform that also provides information (on production, harvesting, marketing, credit, weather, and climate) to farmers through the use of a mobile phone. Currently, four thousand rice farmers use the app in Kenya. Nigerian-based Hello Tractor is a social enterprise that addresses the shortage of rural draft power and labor shortages among rural farmers by creating a network of "smart tractor" owners from which farmers obtain tillage or tractors via SMS. The organization has designed innovative, low-cost smart tractors specifically suitable for small farmers, each equipped with various attachments so that owners can adjust them to suit specific crops and stages of production. Most helpfully in terms of trust and viability, a GPS antenna is attached to each tractor, allowing Hello Tractor to track the machine's usage and collect data on its location, market trends, and uptake. These are innovations for Africa by Africans who thoroughly understand, emerged out of, and have faith in the working of African knowledge.

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Outline of the Book

Intellectual Africa is the subject of the nine chapters of this volume. Their task is not simply one of mobilizing Africans as "native informants" and African languages and orature as archive. One of the contributors to this volume made this critique two and half decades ago when responding to the way Henry Odera-Oruka (1983), Jan Vansina (1986), and V. Y. Mudimbe (1988) treated oral traditions. Cautioning against this colonial way of using African knowledge, D. A. Masolo urged us to move away from a tendency to reduce the producers, keepers, and purveyors of indigenous knowledge to the proverbial "native informant" of anthropology, who is "a mere resource material from whom the scholar extracts and constructs his mute knowledge." Thus "the expert scholar" installs himself or herself "as the systematic thinker (lover of wisdom, scientist) who wades through the ignorance of his interlocutors in order to sift out episteme from *doxa*" (Masolo 1991, 1005; also Masolo 1994, 2003). The book signals a sense of urgency to do something other than simply mobilize African knowledge and lives as fodder for Western theory. As Ngugi wa Thiong'o (1985, 19) says: "Cultural control, as a means of economic and political control, is the most dominant factor during the neo-colonial phase of imperialism, and we as an African people must address ourselves to this if we are really serious about the liberation of the productive forces of African people." It is no longer enough to be content with decolonization as the physical evacuation of the colonizer; Africa must vigorously seize itself with "decolonizing the mind" (wa Thiong'o 1986), to fight the colony within, the colony in us, the colony as us, to resurrect ourselves from the "cemetery of mind" (Marechera 1992).

It is therefore appropriate to start with Masolo, who in chapter 1 offers the inviting provocation that Africa's indigenous knowledge systems have stagnated. There was a bright past indeed, but the light has dimmed; Africans have lost their self-image as innovators and are mere consumers. He wonders whether a reversal of "this culture of self-mortification" (treating ourselves as if we were dead) is possible, how, and against what obstacles. The most spectacular such example of self-mortification comes from the Nigerian scholar Abiola Irele (1983, 3; republished as Irele 1992), who said that the only future for Africa lies in turning toward and following Western culture and civilization: "It is of no practical significance now to us to be told that our forefathers constructed the Pyramids if today we can't build and maintain by ourselves the roads and bridges we require to facilitate communication between ourselves, if we still have to depend on the alien to provide us for necessities of modern civilization, and if we can't bring the required level of efficiency and imagination to the management of our environment." Macien Towa (1971, 1979) is another prime mover of this view. Irele's critics are justified in rejecting a total capitulation of African culture to Western values, because nobody can foretell what identity might emerge. They instead urge Africans to take all the positives they can get from outside, while maximizing the strengths of their own innovations (e.g., Gyekye 1997; Falola 2008; Wiredu 2000).

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Masolo traces the problem of self-mortification to the informalization and trivialization of indigenous knowledge during the colonial moment and since then to something extracurricular to the "new and important" knowledge that Europeans introduced. The colonial school became the venue and source of knowledge, whereas home became simply a domestic space winnowed of any capacity to produce *true* knowledge. There were formed two worlds: one self-styling itself as the producer of secular, natural, or true knowledge (Western) while dismissing the other (the rest) as a world of myths, superstitions, and falsehoods. Those like Paulin Hountondji (1996) who saw myth as abstraction dismissed indigenous thought as philosophy on the basis that it was stagnant, communally produced, and anonymous, the antithesis of proper philosophy. As Masolo notes, Hountondji (2009a) no longer sees indigenous knowledge systems as stagnant and calls for accounting for change and continuity in African practices and modes of knowledge production. For his part, Masolo cites at least two poignant examples—the Maasai and their spear and Egyptian mummification—to illustrate what is scientific and technological about African systems of thought and practices and according to whom. Both are examples of myths and spirituality as abstractions and anchors, inspirations, drivers, and structures of scientific reason, illustrations of "the curiosity of the human mind" and the dynamism and adaptability of African modes of knowledge and material production.

I explore this interlocking of spirituality, communality, innovation, and knowledge production in chapter 2 on *chimurenga*, the arts of war derived from *Murenga*, or Mwari, god of *vedzimbahwe* (or "Shona" people) of Zimbabwe. I show that *chimurenga* is an innovative transformation of surroundings (caves, mountains, rivers, pools, valleys, forests, animals, and trees) into military assets and infrastructure, with or without physical modification. Previous studies reduce *chimurenga* to two historical events: the anticolonial wars of 1896–1897 and of the 1970s. Instead, I see *chimurenga* as a time-transcendent philosophy of security dating back to the migrations of *vedzimbahwe* from the North into Southern Africa. *Chimurenga* is one of many indigenous spaces from which to make critical interventions into the question of the scientific, the technological, and the innovative, from which African reasons and reasoning do not have to be true or false according to outsiders' standards but must be valid on their own merits. I explore the creative labors relating specifically to biological and chemical warfare, which serve as exemplars of a spiritually anchored and inspired creativity. Through *chimurenga*, the everyday or day to day (*zuva nezuva*) becomes a vast *laboratory* (site of creative labors), with ordinary people (*vanhuwo zvavo*) as experimenters and intellectuals in ways specific to their needs and desires and ordinariness no longer equated with simpleton-hood but a normal state of things.

Shadreck Chirikure extends this conversation to African metallurgy in chapter 3, questioning why Africa should be tethered to a Western idea of a laboratory as a built-in space, which undergirds understandings of STI. Such Western-centric conception marginalizes other sites of knowledge production in regions of the Global South such as Africa. Chirikure

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casts precolonial African "laboratories" as places of work, experimentation, and improvisation. Contrary to Western notions of the laboratory, Africa's were not fixed-site installations but included various nodes from "the homestead to the forest, from the cultural to the natural, and from the living to the dead." Chirikure shows that "sites of knowledge production were transient and never fixed on one point," fluid not just spatially but also in their technical and symbolic practices. Metal- and pottery-making sites in particular were "laboratories without buildings." Being temporary allows flexibility and experimentation in terms of furnace design and energy availability across different regions and time spans. With pottery, Chirikure proposes the idea of the homestead as a laboratory, involving the use of clay to form objects according to required shapes and heating them to high temperatures. This process removed water and increased strength. Metal-making was a male vocation, but pottery-making was exclusive to women and could be done indoors to ensure the right degree of heat or cold and the right air or wind conditions, thus preventing cracking. Collection, mixing, molding, drying, firing, and polishing are described in meticulous detail, with hints toward the taboos that governed practice.

Geri Augusto's chapter 4 extends the conversation beyond the physical shores of Africa, emphasizing the role of enslaved Africans not only as STI transferors but also as innovators acting upon this carried knowledge, synthesizing it with knowledge found in the "New World" and creating something entirely new. Augusto points out that the growing literature does not treat the knowledge of enslaved Africans and their descendants as "an integral part of a truly globalized history of science and technology." As she says, there must be room to treat human societies and knowledges as "coeval without having to be judged commensurate," a "different history of science and technology, emphasizing what was creative, inventive, and put together differently." The effort it takes the enslaved to rehumanize themselves after the slaver has relegated them to positions as nonhumans incapable of thought—and thus not technological but the technology themselves—is one of the most poignant examples of innovation in human existence. Thus, through what she calls *plants of bondage*, Augusto returns to enslavement and colonialism with a focus not merely on the sweat, blood, and tears of the enslaved and the colonized, but the enterprise and inventiveness that is required to keep "body and soul together" under circumstances that are supposed to rip one apart from the other. Indeed, one can extend this perspective to the present and turn upside down the negative portrait of Africa as riven with crises—disease, poverty, wars—and, wherever they exist, look at how people innovate survival.

Located in the present, Katrien Pype's chapter 5 on Kinshasa speaks to that very dynamic. Like Mavhunga and Augusto, Pype draws her definitions of *innovation* from indigenous African words, in her case *kosikola*, "to innovate" in Lingala, the dominant language of ba Kinois, the inhabitants of Kinshasa, DR Congo's capital. *Kosikola* also translates into "to choose" and "to deliver" from evil spirits, suggesting that innovation derives from the spirits; it is spiritual knowledge. Thus, "to know" is also *koyeba* or *kozala na mayele*, "to be with knowledge" or "wisdom" (hence smartness) derived from experience rather than formal schooling. *Kozala*

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na mayele becomes a theoretical standpoint to challenge most studies casting smart cities as out of place in Africa and as outcomes of Western technology transfer and African use. On the contrary, there are other way of being smart that Western-centric scholarship does not cover. Thus, Pype proposes to approach "smartness" from below, as ba Kinois see it, and addresses their ways of being innovative and technological in this bustling Africa city. *Smartness* is the capability of one who is possessed by a *nkisi ndoki* (an ancestral or wandering spirit) and therefore a *ndoki*, one who practices not just witchcraft or *kunda* (sorcery), performing either malevolent magic (*kindoki kia dia*, usually by night) or benevolent magic (*kindoki kia lunda*, by day). Incoming things like motorcars, airplanes, kitchen robots, mobile phones, and computers, Pype shows, are all examples of what ba Kinois call *kindoki ya mindele* ("witchcraft of the white men"), distinct from *kindoki ya biso* (our witchcraft). The white man's witchcraft is subjected successfully to "our witchcraft."

The propensity of indigenous traditions to adapt to new circumstances so that they are part of the equation of everyday life today is illustrated clearly in Ron Eglash and Ellen K. Foster's chapter 6. Although there are many makerspaces in America, Eglash and Foster focus on their African counterparts, which continue to multiply and gain popularity across the continent. They are locally and culturally situated, their fixer mentality deeply indigenous in its orientation, as opposed to simply aping European or American maker cultures. The authors cite Senegal's Colobane market and the collective ethos deeply embedded in spirituality; "fixing" is a power given by God himself to the Senegalese people, according to one maker. Meanwhile, in Ghana, street vendors sell new wares while also fixing cell phones, printers, and other electronics with complex circuitry. "They learn their highly refined skills through attachments (or internships)," Eglash and Foster say, with the goal of owning their own shops. They creatively reuse what is otherwise waste: "They are simultaneously pulling the warp of innovation geared toward the future while also weaving in the weft of repair practices already deeply entrenched in their cultures." In Lagos, the hackerspace WoeLab is now renowned worldwide for creating a 3-D printer out of e-waste, and in downtown Accra creative makers meet up and work on their projects in the shared tools, shared space called iSpace. These are just a few of several examples of Africa engaged in creative work at the interface between indigenous traditions and incoming (often invited) things and ideas. Eglash and Foster end where they began: by urging Africa to look into itself for inspiration instead of taking the easy road of importing other people's cultural values.

In chapter 7, Toluwalogo Odumosu asks how, in spite of the self-disadvantaging legal framework Africa has imposed upon itself, Africa's citizens are still able to make mobile technology African. "Can we recognize the African mobile as distinctly African? And if so, what is the nature of its sociotechnical assemblage?" he wonders. "What does it mean to examine how mobiles are being made African?" In answer, he says that Africans are not appropriating merely to use and throw away without adding anything, but are engaged in what he calls *constitutive appropriation*, wherein the act of appropriating is simultaneously one of constituting something into being. Besides the amazing point-of-use innovation that goes

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hand-in-hand with mastery of the lingo and the artifacts and services it denotes, Odumosu speaks to the reality that in most parts of Africa no "wired" telephone infrastructure even existed to prelude the "wireless." Thus, the celebration of Africa as having skipped wiring (technological leapfrogging) en route to wireless assumes this was a deliberate choice and is based on the privileging of the experiences of wealthy countries. Nigerian engineers were not simply "rolling out" universally operative systems but "determined that a fully functional *Nigerian* network has to take into account real users and their particular use practices." Only after that could they engineer a Nigerian mobile. The lesson? "New challenges and practices *inspire new designs and innovative solutions* (overdimensioning) that are then folded into the upstream design process in tangible and substantial ways."

Garrick E. Louis, Neda Nazemi, and Scott Remer mount a robust critique of Millennium Development Goals (MDG) and multiple other innovation and development programs that depend on official development assistance without accountability to Africans in chapter 8. Such foreign aid benefits Western think tanks, banks, NGOs, farmers, and transport companies, and, in the case of the United States, such foundations to "help" Africa are actually hygienic projects that help ex-presidents clean up their images in the eyes of the American people. Deploying what they call an *innovation for development* approach, the authors settle on a simplified definition of *innovation* as "the creation or enhancement of artifacts to improve the human condition." Africa must establish an innovation strategy that "builds upon and leverages domestic capacity." In that way, official development aid (ODA) could be synthesized with these local repertoires and resources to build an Africa-defined, Africa-driven, and Africa-benefiting strategy. The authors thus propose a two-part strategy for national development that prioritizes basic human needs (a la Maslow) as prerequisites for building capability for secondary and other higher-order needs. This commonsense approach holds that "it is not possible to sustain higher-order development processes like manufacturing without reliable basic services, such as water and sanitation." Can't we do both, one may ask? The danger lies in possibly stretching resources too thin and playing to Africa's weaknesses, not its strengths, others say.

The authors make a powerful case for Africans not only as innovative originators of things from scratch. They seek to show the centrality of human needs—the basic ones any human being or living organism cannot do without—and the kind of means and ways Africans seek and deploy to meet these needs. It is here that the authors bring in innovation as strategic targeting of potentially resourceful things "out there" that can be deployed locally to answer these needs. The lazy or arrogant analyst may view such strategic targeting and deployment as merely "use" or even user innovation, when in fact, viewed from Africa, it constitutes a fecund scene of originality. In other words, the authors are saying that innovation developed outside Africa or by non-Africans can, in the innovative hands and minds of Africans (provided they are given the space), contribute to the betterment of living conditions and facilitate other forms of innovation in Africa by Africans. Another way of putting this is that when Africans speak of Marx, Maslow, Kuhn, or Einstein or use a smartphone, computer, or drone,

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analysis misses the point when it only marvels at what these things are doing that makes them technological (problem-solving instruments) in their specific African contexts. Instead, the most important and beneficial question to consider both for Africans and outsiders looking in is this: What are Africans doing to, with, and through these things? This is a strategic targeting and deployment question. It has to be asked, especially as a means test for investing intellect, time, and money in Africa, and, more importantly, it is a question that Africans themselves need to ask whenever the continent's policymakers look outward for potential algorithms to address local problems.

Chux Daniels's chapter 9 closes the book with sobering reflections on official approaches to STI policies in Africa. How is it that an R&D-centric approach can be allowed to guide STI policy in a continent "in which empirical evidence shows that substantial innovation activities occur in the informal economy and significant indigenous knowledge resides in the traditional and rural settings?" Daniels asks. In doing so, he returns us to Masolo's exploration of the origins of the European colonizer's school as "true knowledge" and the homefront as an informalized, even knowledgeless space. He calls for a reconceptualization and expansion of STI to account for "the larger variety of innovative activity in Africa and to address social needs peculiar to the continent." This is an urgent task if the "basic needs" that chapter 8 maps are going to be met. Pan-continental bodies like the African Ministerial Council on Science and Technology (AMCOST) and the mother body, the African Union (AU), recognize the need for STI as a driver of development, but their borrowed definitions of STI are too narrow. How does one exclude street vendors in any narrative of innovation in Africa, for example, when they are a feature of every city on the continent? How can one possibly exclude Nollywood from Nigeria's innovation when it is the fastest-growing economic sector and industry? To illustrate just how Western-centric African measures of STI are, Kenya's M-Pesa is always cited as an example because it is "S&T-based, technology-driven, and prompts product innovation." As Daniels sees it, wherever possible, Africa must be willing to chart a different STI and development trajectory and devise its own measurement, rather than slavishly following the Oslo or Frascati manuals, which Latin American countries have left behind in favor of their own Bogota manual.

The reader is invited to explore what we believe is the beginning of a long walk to the freedom to think from a different place about concepts that we often take for granted and generate new meanings. We no longer look merely at proposing a new perspective to promote a new perception of Africa, but explore African self-perception as a compass from which to plot new futures—futures that are already happening. We just need to open our eyes to see them.

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1
The Place of Science and Technology in Our Lives: Making Sense of Possibilities

D. A. Masolo

Those of us who have the relative advantage of age will remember that in the early years of formal school in Africa we were taught a subject under the general rubric of "domestic artisanry," in which we were taught to carve cooking sticks and to weave baskets and other little utility tools familiar to all of us from their regular household uses. These lessons were regularly taught at a time in the school day calendar when it was considered that the "important" subjects, such as math, English, European history, and European literature, had been learned. "Domestic artisanry" was taught alongside the vernacular, and both soon gave way as the number or depth of "important" disciplines became more demanding. The temporal and incremental trajectory of the separation between the local and the "new and important" knowledge became a visible process of mental and finally also social "dépaysement." Home and school gradually became two vastly different worlds: one ruled by important knowledge about a world that was distant physically, socially, and theoretically and the other by an array of knowledge regarded to be simple and domestic. The disconnect between these two realms has defined how many of us have grown to classify knowledge, claiming sometimes that indeed they are and ought to be kept apart. The recent controversy over the concept of *ethnophilosophy* or whether the indigenous can incubate and produce philosophy stems at least in significant part from the heredity of this dichotomization between domestic and simple on the one hand and new and sophisticated on the other. One needs a quantum leap to transition from the former to the latter.

In his controversial essay "Le Décollage conceptuel: conditions d'une philosophie bantoue" (1965), Franz Crahay suggested as much—that in order to transition to philosophy, African thought required a takeoff or aerial lift from the mundane and familiar realm of myth to a flight into the higher echelons of abstraction. Whether in philosophy or in the everyday making of tools and other forms of transforming the material world, knowledge is a mental characterization of the sense and usefulness of the familiar for the management of the complex world value. From a pragmatic point of view, mind is an extension of nature; hence, its growth is commensurate with the exigencies of adjustment to the variety and changing character of the environment. In other words, mind is always part of place. Hence,

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in a significant correction of Crahay, while remaining faithful to keeping the "indigenous" and the "scientific" separate in the ensuing pejorative characterization of ethnophilosophy, Paulin Hountondji rightly pointed out that myths are already forms of abstraction—suggesting that the difference between the philosophical and the nonphilosophical had to be sought elsewhere other than in differences between abstraction and nonabstraction. That is, thought of any kind, including the construction of myth, is always an abstraction (Hountondji 1970). Hountondji's charge, in turn, was that indigenous modes of thought were not philosophical for two major reasons: First, philosophy is a mode of thought that is individually owned, which is quite distinct from the anonymous and shared beliefs of ethnic communities as exposed only in the works of the authors who describe them. Second, and perhaps even more importantly, philosophy is a body of knowledge that is driven solely by critical considerations of thought. Due to this second characteristic, philosophy is a kind of thought that is always changing, meaning it is expanding and growing in understanding, and this implies that philosophy is about thought, and therefore general—it supersedes communal acceptance—in its character.

In the years subsequent to the Crahay-Hountondji debate over the philosophical relevance of indigenous modes of thought, and as the idea of modernity and its relation to indigenous knowledge systems grew, the debate over ethnophilosophy extended beyond philosophy. Despite sharp opposition, Hountondji's point about growth driven by critique as the character of philosophical knowledge has spawned new critical considerations of the nature of knowledge at indigenous levels. As intimated earlier, the fresh looks pose critical questions, including whether or not indigenous knowledge systems lack capacity for innovation and growth or whether, as brought into question in the idioms of the separation between the domain of modern school and that of home, indigenous knowledge has any place in contemporary society.

Indigenous Knowledge and Innovation

More recently, Hountondji (2009b) has softened his critique of indigenous knowledge systems as stagnant, perhaps realizing that no human knowledge bears that description. From a purely pragmatic view, toward which his recent stand has shifted, the human mind as an adaptive tool transforms commensurably with the transformations in the rest of nature around it, thus suggesting a plurality of applications to varieties of contexts in the place of a universalistic and conservative notion of truth, such as is espoused in the mid-twentieth-century analytic tradition (Hountondji 2009b, 13–15). Not only do people adjust their principles of rights in relation to changing circumstances of availability of resources, they also adjust them in relation to changing conditions of foreign relations, meaning that when encounters with people from other ethnicities or distant lands occur, they demand redrawing of boundaries to allow access to basic resources like water for pastoralists. Settlement of such issues may not always come easily, nor does it occur quickly enough for all involved, but it does occur as part of social dynamics. Continued land or boundary reclamations and sometimes

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conflicts around the continent are some of the indications of matters not settled by past agreements, at least not to the satisfaction of everyone affected. In light of these and other considerations, Hountondji now thinks that the more enlightening approach to understanding indigenous knowledge is to ask how today differs from yesterday, meaning the past in general, or how the manner of doing things today differs from how they were done yesterday—meaning in the past, the ever-recessing dimension of time.

Here is an example: The Maasai, the proud pastoralist people who inhabit the plains of East Africa (southern Kenya and northern mainland Tanzania), are admired for, among other things, some of their material cultural possessions, especially the spear that most adult men carry almost ubiquitously. The spear is the symbol of adulthood among the Maasai and is a major protective weapon. Although the spear is a widely used tool across Africa, the Maasai spear occupies a special place by itself for its fame. The most famous among an assortment of types (see figure 1.1) is the variety known as the "Lion spear" (figure 1.2), and a well-made

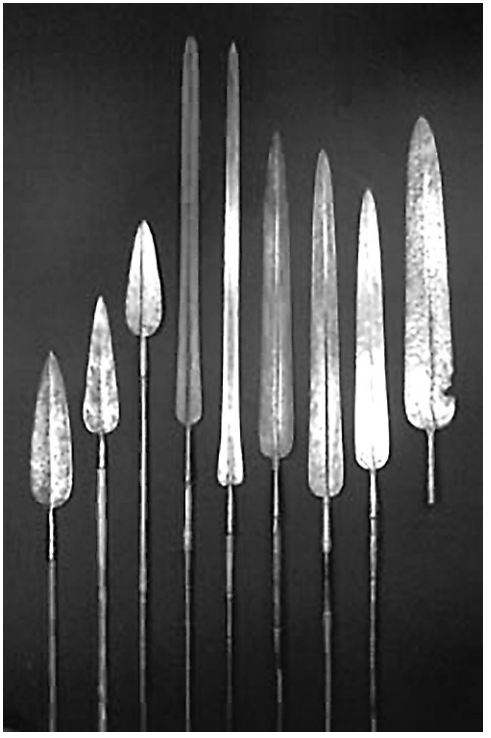

Figure 1.1
A display of Maasai spear designs. The first three on the left are the everyday spears that the Moran (warriors) and elders carry at all times. The rest are different ceremonial spears designed for different age groups. The last two on the right are generally carried by elders, while the long-bladed ones in the middle are carried by younger adults.

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Figure 1.2
The ceremonial spear with a short handle in the middle, a long blade on the one end, and a long, sharp rounded other side.

one is a visual beauty. On one end is a double-sided, shiny, razor-sharp blade that usually measures at least three feet long and about two inches wide. It is both decorative and functional (figure 1.3). It is mounted on a wooden handle measuring between one and one and a half feet long, and on the end opposite the blade a differently shaped spear of roughly the same length as the blade is mounted, but with a long, round, and pointed end.

The Maasai have not always had this variety of spear. Historians and archeologists date its appearance to the mid-twentieth century or perhaps a little earlier. One would be led to believe from this dating that its appearance coincided with the sudden abundance of iron and other metals as a result of building the East African railway lines across Kenya and mainland Tanganyika during this period. Thus, although the Maasai had probably limited the production of spears and other metal-based tools to cultural needs, relative excess of availability of iron—usually obtained in raids on the field depots of the railway-building company—drove many a smith's imagination to new and innovative styles that became symbols of status in the community. The uses of these aesthetically rather than functionally driven objects became part of the occasional or periodic social gatherings at which individuals showed off what they could afford as a result of their large holdings of cattle.

Maasai culture has been especially exposed to tourist observation as well as commodification, partly due to Maasai territorial habitation of lands that generally border some of Africa's plains rich in wide-ranging wildlife. Cordoned off as national game-viewing national parks, the status of these vast territories as tourist destinations has exposed Maasai culture to tourists who have to pass through Maasai *manyattas* (homes or villages) en route to the parks. This exposure and the foreigners' curiosity that accompanies it has pushed Maasai smiths to

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Figure 1.3
A young adult from the Elgon Maasai community along the western Kenyan border in ceremonial gear. He is holding the ceremonial spear and a decorated buffalo hide shield, and he wears special ceremonial headgear.

produce partly for the relatively lucrative tourist market. This, argues Sidney Littlefield Kasfir (2007), is only one aspect of the constant variation of the Maasai spear design that reflects the generational succession of age groups and the egalitarian set the specific design symbolizes and also distinguishes them by rank (younger or older) from other age groups. Her point applies more to the functional rather than the decorative (Lion) spear. Also, her study analyzes the spear tradition among the Samburu, a more northern (Mount Kenya) group that is also a Maa-speaking group related to the group conventionally referred to as Maasai to the south. For most practically comparative purposes, except in dialect and other details

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unnoticeable to the outsider, Samburu and Maasai are nearly identical, including in their spear traditions.

The making and social role (age grading) of the spear among the Maa-speaking peoples of East Africa are marks of ideas central to the general concept of innovation related to material culture. Because it is constantly modified to suit the role of symbolizing time and social identity of different age-based subgroups, the Maasai spear evinces innovative imagination across time in the ethnic history of the Maasai. Beyond this, the dynamics in the design appearances and variations evince the presence of communal concurrence following possibly protracted debates on design choices that do not repeat the past. In other words, the process involves a dialogue between individual citizens whose proposals are critically discussed on the way toward a selection that reflects agreement on a communal identity in its transition through time.

But the drawing of the symbols of a collective historical progression is not the only factor that stands out in the example of the Maasai spear stylistics and design. In addition to the imaginations and symbolizations of time, the management of the history of the spear in its relation to the history of the community is built on the sustainability of the process itself. Driven by an endogenous sense of value and of goals, the community marshals available resources, or seeks their supply, in service of their endogenously defined goals. In other words, because the goals are not imposed from the outside, they can be managed—changed, modified—from within the community itself based on the prevailing circumstances and challenges of any time.

It would be misleading to suggest that the view of the spear as depicted thus far is not without its own discontent. Like every tool, the spear or the notion of technology in its general sense is created to reflect a society's more complex view of value, within which the valuation and focus given to a specific object finds its own position in the complete puzzle of things. Not only am I trying to say here that technology is not amoral, I am also saying that the morals under which a technological implement finds its acceptance are neither necessarily nor always unquestionable. The Maasai, for example, are a male-dominated society in which the image of society is designed to appear through the image of its male members. Women do not handle the spear—something that applies to most spear-wielding communities across the continent—the most important and visible symbol of the community's public identity. Through an intricately defined curriculum vitae, the male is expected to go through stages that will finally lead him to be proclaimed a *moran* (warrior) of his community. This is the ultimate goal and image of every Maasai male child; it is the social rank he aspires to. A *moran* is expected to be fit and fierce, the ultimate protector or defender of the *manyatta* and finally the entire community. Carrying a spear (for adult males) and a round-headed wooden *rungu* (club) completes the outward appearance of a Maasai male, and every male child grows up learning and absorbing the values of these characteristics—that they represent the security and integrity of the *manyatta* and community at large. Their collective duty is to protect their people and their sacred possessions—the cattle. Given the predator-infested nature of

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their traditional territory, it is the duty of Maasai *morans* to take their cattle to pastures, and there was a time when killing a lion was part of a boys' rite of passage to mark entry into adulthood or rank of *moran*. This resolute sense of identity has made it possible for members of the Maasai community to proudly withstand the influences of newcomers while the unity that it spawns made it possible for the Maasai to ward off any challenges of the more numerous neighboring communities.

By contrast, Maasai women, trusting their sense of safety to the unquestioned loyalty of the men to the integrity and values of their community, need to carry no more than a stick with which to shoo goats or other young domestic animals (sheep, calves, etc.) in a desired direction or to shoo a snake during an undesired encounter. The duties of women include the construction and taking care of the *manyatta* as well as taking care of other domestic needs, such as fetching water and firewood. As issues related to gender parity or disparity in how access to resources and distribution of roles and responsibility in society have risen and dominated how people analyze and assess social progress as a global discourse, they have influenced an increase in Maasai women's participation in socially visible activities, including serving in roles that include participation in local and national leadership and in professional fields.

The case of the Maasai serves two purposes here: First, it provides a path to understanding an important aspect of the Maasai's material culture independently as it relates to innovation understood as a constant modification of tools. Second, it serves as a microwindow for identifying, on a more general and broader scale of development and planning goals, what African governments have persistently failed to appreciate and do—that the everyday person, the ordinary folks, both understand technology and know selectively what kind of technology can be positively incorporated into their value systems. The Maasai, and any or all other peoples or communities who use art or other form of product as markers of specific information in social history and structural arrangements, have shown, as evidenced by the history of their use and constant modification of technology, that they are capable of answering the question of what it means for anything to be good. However, governments mandate policies that work with imported concepts of development that are implemented on a top-down basis with little or no input by those to be affected by the specific program implementations. Also, the government places itself into a position as a victim of the proverbial saying that "the person who holds the bone controls the dog's tail wagging and drooling." The dependence of African governments on foreign donors for aid or capital reduces the degree of their autonomy in defining and paving their own development agenda. As a result, African governments have failed to be innovative in their definitions and approaches to development as they are restricted to following the agenda as set by the international lending institutions like the World Bank and the International Monetary Fund, or by the single lending governments in bilateral lending/borrowing agreements. The result is that African paths to development imitate those of the West irrespective of their relevance to the needs of African peoples.

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Going back to the beginning of this narrative and the idiomatic but also historically real separation between a modern world represented by the school and its cognitive world on the one hand and the world of home that is quickly relegated to the rank of irrelevance and triviality on the other, one sees an important explanation—albeit one among possibly many others—for why African governments persistently struggle to define and consequently fail to achieve development goals. To be more precise, unlike the Maasai, they pursue what they have not defined and often have no endogenous visions and means to attain them. By contrast, innovation is borne of freely thinking citizens who, as part of their own communities, identify with the values, directional goals, and challenges and struggles that stand as obstacles to these ends. In other words, innovation comes out of different levels of participatory discourse about prevailing needs and about available local human and material capacity to tackle them. Innovation is not about breaking Guinness records; it is about novel means to tackle persistent problems as they affect all (local, national, or, where applicable, regional) levels of community and its projections. The Maasai's relative resistance to the influence of "foreign" values is a living example.

Africans' adaptation of the cell phone into their social world is a much-discussed example of adaptation of technology. Innovation does not equate to invention. Ingenuity includes intellectual perceptivity that allows one to see possible adaptations of a tool already in existence elsewhere, and Africans' use of the cell phone to sustain and better manage what was once referred to by critics of Africans' belief in or practice of distribution of wealth among members of extended families as part of "taking care of each other as based on no other factor than 'love thy kin'" is an excellent example. I first heard and witnessed telephone banking among villagers in my home country of Kenya long before it became a feature of cell phone use in America. Terminology like *M-Pesa*, *Sambaza*, and much more I have not been able to catch up with signals innovative transformations and adaptations of technological tools built elsewhere but given completely new, different, and culture-specific uses. In these and other senses, the cell phone has become an African technological tool. Most Kenyans, including my octogenarian mother who can neither read sentences nor write (but who is an excellent historian and mathematician and serves as the treasurer of the several village women's organizations she belongs to), perform almost all of their financial transactions via cell phone, including payment of bills, local and international money transfers, and making purchases in the marketplace. From this cultural perspective, *foreign* is an originatory adjective that describes non-Maasai origin, even if a value so described is from a neighboring ethnic community.

The Egyptian Mummification Saga

Innovation is spawned by the needs and imaginations of the world. We all know the origins of what has become one of the most widely practiced funerary rituals outside Muslim burials—namely, embalmment of a dead body. The uncontested origins of this

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contemporary science are to be found in the ancient Egyptian myth of the "other world" to which people were believed to cross once their time in this one ended. Either because ancient Egyptians believed that one had to be prepared for this journey in meticulous detail over several days or because funeral rites took so long that the body would decompose rather fast while exposed to high heat of the sun and be odorous to mourners, the body was "cleaned" of the organs and entrails that produced fluids and caused stench. In addition, the body was treated with natron, which dried it to such levels that decomposition was delayed for a long time. It is still not clear to scientists exactly how ancient Egyptians discovered natron, but it is no surprise that the exigencies of culture must have led to a search for a solution, and it does not matter whether it was a concoction arrived at by accident or an imported item from a distant land. Elsewhere, wherever it may have been procured from, it did not have an impact similar to the one it had on ancient Egyptians and their culture. The peoples who inhabit the region adjoining Lake Natron along the western border of mainland Tanzania do not show any records of practicing embalmment despite the saturation of this chemical in the lake. In any event, the history of Egyptian mummification predated the migration and settlement of the current inhabitants around Lake Natron by several millennia.

In a recent, spectacular publication (*African Cosmos, Stellar Arts*), Christine Mullen Kreamer, deputy director and chief curator of the National Museum of African Art at the Smithsonian Institution, captures a glowing synthesis and interaction of African cultural astronomy and the arts as a contributing part of the long history of the human endeavor in the creation and sharing of knowledge (Kraemer 2012). As Johnnetta B. Cole, director of the National Museum of African Art at the Smithsonian Institution, states in her foreword to the book, Kreamer's "passionate commitment to the peoples and cultures of Africa and an understanding that works of art dating from ancient to contemporary times are powerful vehicles for engaging scholars, connoisseurs, and the general public in understanding Africa's role in the production of knowledge as part of global intellectual history" (Cole 2012, 8).

Long before the refinement and practice of theoretical reason as we know it today, African societies, like most human groups around the world, already had embedded in their cultures expressions of their relationship with reality: with the stars in the firmament above, with the material world around them, and with what they understood to be the mediating connections between these polar points of reality and how their own situations figured within the expanse. They had narratives to account for duration, such as sizing themselves up against the material world that appeared not to change as fast as their own relatively short lives. These narratives often include accounts of origin, of the meaning of being in the midst of a vast world, and of the human transitions between them.

Thus, myths and imaginings about the cosmos make up some of the most fascinating and inspiring indicators of the curiosity of the human mind. Noting the shifting positions of heavenly bodies above and relating them to climatic changes in their own worlds, communities learned to use these relational events to regulate their own travel and their agricultural

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and ritual practices. To this extent, cultural astronomy traverses multiple domains of life: science in seasonal planning in relation to economic production; religion in relation to rituals aimed at acknowledging and honoring the deities who are sometimes associated with the powers and significance attributed to some celestial bodies and their believed causal relations with the cycles of life and (re)production; the expressive cultures in the visual and performing arts as humans symbolize in sculpture and adornment or reenact and celebrate their relations with the deities, through mask and dance, respectively.

As is more discernible from the treatment of the dead, including choice of place and modality of interment, than from oral or written treatises on human nature, the idea of the meaning or purpose of human life is a crucial subject of early human thought. However the deity was conceived, these seminal thoughts of humankind led to other ideas, not only about the nature of the deity itself, but also about the implications of recognizing its existence and relations with humankind. Ideas erupted in human imagination, especially about social order, about moral codes through which humans would regulate their conduct not only with each other but also with the deity itself and with the world at large.

Observation of the regularity of death and inferring its inevitability for biological organisms led humans to questions about the end, especially for humans; for example, think of a curious child talking to her mom by the fireplace a few days after her sibling, Aloo, dies. Oblivious of the pain engulfing her grieving family, she poses the question: "Mother, where do people go when they die?" "They go very far," the mother responds, hoping the little child will stop. But she goes on: "Can I also go there? And will you too? Why do people have to go there? Why can't they just stay here? And why did Aloo not go there? Will Aloo come back?" To the last two questions, the mother answers, first with some difficulty, "No, people don't come back after they go there; it is too far." And then, with her own question, the mother asks the child: "And how do you know she didn't go there?" The response: "Because she was buried in that large hole in the back of our home. I don't want to go!" To avoid further suffering the pain of a mother's grief, the mother gets up and starts to busy herself with ensuring that all the chickens have come in as night falls.

Out of innocence, the little girl has asked the big questions adults have never been able to provide satisfactory answers for, at least not yet, or not conclusively enough to stop their asking. Ideas in human imagination have often led to or justified specific religious, social, and moral practices and the making of artifacts around where humans live. The handling of the bodies of the dead, the places of burial, types of grave, adornment of grave interiors, the coverings over them, and how the surroundings of the graves are kept all depend on how people define human beings and their lives, and what death and the afterlife mean. Archeological digs and scholarship have revealed the depth of human imagination in the realm of life and immortality, and no group surpasses the Egyptian people of antiquity and their rich civilization when it comes to the mix of science and religion in the futuristic projection of life beyond its worldly limitations and shortfalls. As if to give answers to the questions of the inquisitive fictional child discussed earlier, ancient Egyptians were believers in human

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immortality—not just in spiritual terms, as came to constitute the core of Christian faith and philosophy, but immortality of the complete human being, almost as she or he had existed in this world.

Among the questions that remain vaguely treated by believers of immortality is whether the dead retain or shed the social status they had in their worldly lives. The trichamber edifice erected in Christian imagery reflected a belief in the capacity of embodied life to affect the purity of the soul as a sign of obedience to God, thus determining where one's soul went after the death of the body or the termination of the worldly life and ultimately following the final judgment. Like Christians, Muslims believe in God's creation of seven heavens, of which the Garden of Eden is the highest, or Paradise. For both systems, this is where God placed Adam and Eve, the primal ancestors of humans in their respective cosmologies. In both systems, transgression of God's commands by humans or their ancestors occasion the onset of evil to which humans become susceptible. God's messengers over time culminate in one chief messenger, whose teachings become ultimate and second to none but those of God. To Christians, this messenger is the Son of God himself, Christ or Savior. To Muslims, it is Mohammed, the Chief Prophet. At the end of time, there is resurrection of the dead and a final judgment for the living and the dead. Those judged good in the eyes of God go to Heaven, whereas the wicked descend to Hell. Henceforth, each group endures its fate for eternity.

Long before the Christian and Islamic traditions and probably like people in other civilizations, Egyptians thought of otherworldly life as reflective of one's status in this life, so they prepared the bodies of the dead in accordance to what they believed would fit their needs in the next life, commensurate with their social status in this life. They held their kings, historically known as the pharaohs, in the highest regard among humans. They gave these rulers special attention in death as they had done in life. The imaginations of ancient people regarding the transitions between earthly and other life played crucial roles in how ancient Egyptians designed, constructed, and adorned tombs in line with a dead person's rank in his or her social life.

As modern archeology shows, preservation of bodies under natural conditions has occurred in many parts of the world where favorable climatic and other nondestructive conditions allowed, and this may have been the case in Egypt too in some respect (Dunand and Lichtenberg 2006). Contemporary fascination with body preservation in ancient Egypt exists because it was a deliberate process linked to a cultural cosmology that regarded the cosmos as a span of transitions in which humans were believed to transition from one province to another in as lifelike an appearance as was possible. The practice of body preservation sounds even more spectacular when considered as a process that was aimed at providing an alternative form of preservation to the effects of the warm sand. It has been suggested that deeper graves and underground chambers were adopted to counter exhumation by wild animals and grave raiders, thus leading to the use of embalmment methods to preserve bodies at the greater and chambered depths. The result, says Robert B. Partridge, is that "we can look

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directly into the actual faces of the long-dead Ancient Egyptians. We can learn a great deal from their bodies about how they lived, what diseases and ailments they suffered during life and sometimes how they died" (Partridge 1994, 1). In addition, with modern medical investigative technology like the X-ray and detailed tissue examination techniques, scientists and interested members of the general public now also can learn about the dietary and general health of Ancient Egyptians (David 2008).[1]

The practice of mummification reveals the ingenuity of ancient people, not only in responding to their cosmogonic representations but also in minimizing the repulsive consequences of having a dead and decomposing body present for a prolonged time while burial preparations were underway. To perform mummification with considerable success, knowledge of human anatomy was crucial. Early techniques included removal of internal body organs—a process called *evisceration*—to minimize swelling caused by bacterial gases along with detailed bandaging of the entire body, sometimes with a layer of plaster over the bandaging to prevent direct skin contact with air. Internal organs—except the heart, which Egyptians believed to be the center of life and intelligence—were removed to prevent bloating and unpleasant smell. They believed that the dead would need their hearts in the next world. Later, Egyptians used natron[2] to perfect the embalming process.

Accounts of when the use of natron might have been introduced into Egyptian funerary practices or how Ancient Egyptians discovered it are sparse. What is obvious is that its use reveals an ancient people's environmental knowledge and classification of ecological items by their composition and uses. The same could be said of the now-famed knowledge and use of the highly poisonous plant sap benge by the Azande of Southwestern Sudan for one of their oracles.[3] What appears clear is that both the preparation of permanent tombs and waterways influence how people shape their lives and especially how they organize their productive activities, like agriculture and pastoral life. The Nile gave Egyptians the advantage of a resource that enabled them to produce alimentary needs. Cradling along the Nile Valley precipitated migrations from afar and led to the formation of permanent settlements over time, thus leading to the adoption of a sophisticated social organization with the Pharaohs as rulers. Further south was the kingdom of Nuba, which was flourishing in agriculture and trade. Its citizens might have been travelers down the Nile who would market their products and interact with people farther down the valley. Because the limestone with which the pyramids were constructed was natural to the region of the Nuba kingdom, their participation in the making of the civilization that came to be identified with Egypt has continued to intrigue historians. Under these circumstances, the Nile might have precipitated a sense of "immortal nourishment and continuity and richness of life in the imagination of those who settled along its rich valley" (Harman 2008; Goldschmidt 2008).

The simplest form of belief in the future life was that of the continued existence of the soul in the tomb and about the cemetery. As a result, Egyptians left a small hole in a dead person's tomb chamber to allow in-and-out movements of the soul, which was believed to wander around the cemetery compound. Sometimes, family members of the dead would

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make visits to the tomb, during which they would lift the small covering in order to have a conversation with their deceased kin. Often, people made funeral offerings of food, water and wine, and sometimes also favorite ornaments of the dead, which were placed in the tomb for their use. For a king's tomb, it was not unusual to find it divided into separate chambers furnished with kingly possessions.

Egyptians looked upon the world beyond as a replica of life on earth. In that world, Osiris ruled firmly, because all dead belonged to him. Souls labored just as people in this life did, reaping the yield of their farm labor, the main occupation around the Nile delta. Because Osiris's kingdom was thought to be separate from this world and life, both visually and in imagination, its location constantly shifted from the increasingly familiar to the distant horizons that living humans could access only in their minds.

According to another view of the future, souls went to join the sun god Ra in the distant West, where they prayed to be allowed to enter the eternal light that triumphed over darkness. No longer associated with occupations, this system presented the solemnity of divine companionship as a sufficient goal for the soul. This shift in imagining the future resulted in changes in the furnishing of the tombs as well, because all the souls would need were boats to facilitate sailing to the setting sun in the West. Hence, either model boats or pictures of boats were placed in the tomb instead of the farm tools provided in previous systems.

So elaborate was the Egyptian deistic galaxy that scholars have preferred to exercise restraint when it comes to the count of ancient Egyptian gods, because each city appears to have had its own set of deities. Some of the most amazing artifacts of ancient Egypt include the temples built by successive Egyptian civilizations and kingly dynasties to honor these deities. Privileged by the status of location of human origin, Africa would be a natural pick to bear some of the oldest civilizational landmarks of human history, like the Egyptian pyramids that present as much architectural wonder in stonework and masonry as they do anatomical knowledge of the human body and preservative techniques, without ignoring the religious imaginings associated with mummification. Architecturally, the skills noticeable in the work on the pyramids is visible also in the shaping and erection of the *stelae* (pillars) in the region of the ancient kingdom of Axum farther south, in what is present-day northeastern Ethiopia.

Technological innovations that become significant aspects of cultural beliefs and practices or cultural beliefs that spur innovations as communities adapt to their different environmental conditions are found everywhere. Sometimes, social conditions of living side by side bounded by conflicting territorial claims may force communities to find solutions for living with the physical conditions that are present. Many nomadic communities that live in hot weather conditions across Africa have invented ways to manage their food supplies. The saying "necessity is the mother of innovation" applies to all human communities. People look for what they need. If they do not already have it, they try to borrow it, and if no one in the neighborhood has it, then they have to find a way. That is the spirit of human innovation everywhere and throughout time. Traders trekking across the now-famed trans-Saharan

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routes depended on animals that could persevere in desert conditions with little water and vegetation and deep-sand terrain due to their adaptable physical makeup. As a result, camels and goats became the traditional livestock, with donkeys kept principally for carrying loads. It is no surprise that camels and goats are common among all nomadic communities across the continent, from the Tuaregs and the Fulani of West Africa to the Somali, Rendille, and the majority of Oromo-speaking peaking peoples of East Africa. In addition, the innovation of instruments for storage and transportation of drinking water for humans is common and shared knowledge and a shared technique among these communities. Carefully sewn sacks made out of animal hide are common and perfect instruments for carrying water while keeping it cool for a long time. The Rendille of East Africa learned long ago to dry their milk into powder, which enables them to keep it safe, easy to store, and able to be carried long distances. In addition, they use ghee from camel milk as a skin oil for protection from sunburn and insect bites. The point here is to note the manifest innovative cultural knowledge forms and practices and technological adaptation to environmental conditions as communities manage their lives in sync with the changes and regenerative cycles of the environments around them. When Francis Bacon wrote the now-famous phrase to the effect that "knowledge is power," he described human taming of nature throughout history, an accomplishment achieved by designing and implementing techniques to reach goals that are sometimes cultural and merely practical at other times.

Innovation and the Dangers of Internationalization: ICIPE

Let's return to the present. In other fora, I have mentioned the birth of institutions the missions and scientific objectives of which have been driven by concerns about local needs. One such institution is the International Center for Insect Physiology and Ecology (ICIPE), founded in 1970 by the late Kenyan biochemist Dr. Thomas Odhiambo. Founded to educate rural folk on the benefits and menaces of insects with which humans share their habitat and headquartered in Nairobi, Kenya, but now with subcenters in twenty-four African countries, ICIPE educates people to know about and to be able to distinguish between beneficial and harmful insects in their different ecological settings, thus empowering them with knowledge of how mosquitos and other insect vectors of tropical diseases carry and transmit such diseases as malaria, the sleeping sickness, or the river blindness and how some of these maladies are harmful also to their cattle. Thus, people are empowered to take measures to protect themselves and their economically crucial resources and therefore increase their capacity to be more productive and improve their health and quality of life.

In addition to human health, ICIPE also educates people on the "culture and social systems" of menacing insects such as termites so that those people can be empowered to control their empires and destructive effects on crops and human abodes while receiving training to farm or use wild silk worms for the production of silk and increasing their bee-keeping activities for the production of honey. In 1987, ICIPE received a new charter under the

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Stockholm Convention that established it as an international center for the study of insects—a Stockholm Convention Regional Center in Kenya—which essentially made it part of the United Nations Environmental Program. Today, besides working alongside indigenous experts in the areas covered by its mission in order to strengthen their capacity in agricultural production and preservation of crops and harvests as well as to build new ones, ICIPE also trains scientists at both the doctoral and master's degree levels as a means to expand its service to people.

Again, as noted previously in the discussion of the negative effects of aid on local innovative capacities, ICIPE is likely to be perceived by local communities as something too grand to be locally meaningful as far as the freedom of local folks to think creatively about their needs is concerned. With international control over their heads, organizations like ICIPE are more likely to depend on imported tools of their trade like industrial chemicals than to empower local people to expand use of local, environmentally recycled or chemical byproducts and therefore use more readily available control methods and means.

Conclusion, or in Lieu Thereof

There is enough scientific and technological capacity to sustain most conditions of life everywhere and anywhere. As the world faces threats from overuses of industrial products, the age-tested methods of communal management of the environment suddenly appear to be more appealing and safer avenues to follow. However, pursuing such avenues will not happen soon enough unless African governments learn to resist the pressures from aid donors to define and push development practices from the viewpoint of the donors' world. To reverse this already harmful trend, there needs to be a thorough decentralization of development management and encouragement of more involvement from local communities in the definition of development goals, because this is likely to encourage innovative thinking, and an aim to limit goals to use available resources or those that can be procured with little or no pressure from conducting development from a beggar's position; in contrast to the Maasai model described earlier, "the person who holds the bone controls the dog's tail wagging and drooling."

There is another lesson to learn from the Maasai: They are proud people who could not care less about what, for lack of a better term, is called *modernity*. Individuals from the Maasai community have infiltrated all sectors of contemporary lifestyles on the strength of education at all levels, and, like all other citizens, they hold all kinds of positions made possible by modern economy. However, Maasai lands outside urban centers are not experiencing loss of habitat at the fast pace common in other parts of the country. Despite a vibrant economy from their cattle and tourism, the Maasai people interact with modernity on their own terms, preferring to proudly adorn themselves in traditional garb anywhere they go and teaching all of us that small is beautiful and that tradition and modernity are not as oppositional as the enemies of African traditions and customs have waged a cultural war to make them seem.

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Notes

1. The University of Manchester in the United Kingdom is host to the now world-renowned Mummy Project that applies biomedical research techniques to the study of Egyptian mummies.

2. Natron is a natural product, a mixture of sodium carbonate decahydrate or soda ash and sodium bicarbonate. It preserves by absorbing all fluids or moisture from the body, thus leaving it in its intact state. Lake Natron within the Great Rift Valley in northern Tanzania is named for its highly concentrated levels of this chemical mixture, which petrifies all birds and animals that fall into it, occasionally including the versatile flamingo, with its long legs, wide wingspan, and slender body.

3. Popularized by the British social anthropologist Sir E. E. Evans-Pritchard in his widely studied *Witchcraft, Oracles and Magic among the Azande* (1937), the chemical composition of the sap may not have concerned the Azande as much as what they used it for—namely, the conduct of the oracular procedures to determine the guilt or innocence of persons accused of causing the death of others by witchcraft. Thus, also, the practical desired results in preparing bodies for arrival in the next world must have been the goal and interest of Egyptians' practice of culture in ancient times rather than the scientific or chemical composition of the materials (now known to have included Natron as a key ingredient) used in attaining the results. Many examples can be cited to show the innovative minds of everyday folks as they searched, procured, and used materials in their habitats toward the attainment of ideals defined in their cultural knowledge and imaginations. Knowledge of poisonous saps extracted from plants and used on arrow heads in hunting by many communities, or knowledge by the Turkana people of northeastern Kenya of the powerful and deadly poisonous nature of crocodile bile that made them expert handlers of crocodile carcasses or dealers in crocodile bile-poison are just a few such examples of taxonomic knowledge of the natural habitat that African communities have but remain untapped for gainful uses by other people. Thus, it did not matter whether the preparation of bodies for arrival in the next world could not have been norms without a sense of stability in social structures and expectations. The same cannot be said of much of the rest of the continent at the time. This stability suggests that migrations into ancient Egypt introduced peoples with different cultural backgrounds, thus leading to great diversity of culturally based skills that would require organization to channel into productive activities in response to needs that were changing in both volume and variety. This would suggest, as is widely believed by historians, that influx into Egypt from as far away as Mesopotamia started prior to the 5,000 B.C.E. mark, when the Pharaohs first came into existence as the world's earliest advanced form of ruler.

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2
The Language of Science, Technology, and Innovation: A *Chimurenga* Way of Seeing from *Dzimbahwe*

Clapperton Chakanetsa Mavhunga

Why *Chimurenga* Now?

Chimurenga refers to means and ways of defending or fighting among *vedzimbahwe* (those of the houses of stone, *dzimba dzemabwe* or *dzimbahwe*), who since colonial times have been called the Shona. *Dzimbahwe* (or *dzimbabwe*, single *imba yebwe* [house of stone]) are the structure after which the country *Zimbabwe* (a big house of stone) is named, in homage to Great Zimbabwe, the biggest such complex.

Since the 1970s, Zimbabweans have used the term *chimurenga* to refer to the 1896–1897 and 1960s–1970s wars of independence against the British settlers, but I argue that the concept has a much deeper meaning. This chapter addresses at least three defining features of *chimurenga*. First, it refers to the arts of war derived from *Murenga*, hence *chiMurenga*, the way of *Murenga*, or spiritually guided warfare. *Murenga* is another name for *Mwari* (God).

Figure 2.1
Great Zimbabwe, or Dzimbahwe, the largest of the houses of stone after which the Republic of Zimbabwe is named.
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Second, it is an approach to war involving the whole community, not just those carrying lethal arms. Third, *chimurenga* is an innovative transformation of *zvakatikomberedza* (surroundings; caves, mountains, rivers, pools, valleys, forests, animals, and trees) into military assets and infrastructure, with or without physically modifying them.

The spiritual aspects of *chimurenga* have received treatment only with respect to the 1896–1897 and 1960s–1970s wars (Ranger 1967, 1985, 1999; Lan 1985; Daneel 1995). However, analysis is historically tethered to its specific milieu; this chapter takes *chimurenga* as a space from which a different, African story of *ruzivo* (knowledge), *kugadzira* (making), and *kusika* (creating) might be told. Read carefully, there seems no need to burden *chimurenga* with externally assembled theoretical frameworks that render it illegible; *chimurenga* speaks for itself from multiple indigenous archives of deep *chidzimbahwe* that are also philosophies.

The politics of writing *chimurenga* is such that one has to refuse to accept *chidzimbahwe* as a secondary language whose principal concepts must simply be translated into English and consigned to a glossary. On the one hand, the anonymous reviewers (to whom I owe an unpayable debt of gratitude) felt the reader might get lost if the translations were only one-offs. On the other hand, as the author, I rejected outright consigning *chidzimbahwe* concepts to the glossary and remain with a completely English text. After all, the audience of this text is not just Westerners who may feel that the vernacular names are slowing them down and therefore prefer a glossary. The readers are also Africans whose languages are often expunged from the science and technology narrative in the conventional editorial processes and narrative styles. I did not want to give the impression that my native language is secondary and that English trumps every other language. After all, writers whose native tongue is not English are always being asked to write and read in English without English language speakers and writers being ever required to do the same with African languages.

To return to *chimurenga*—the description and location of the vernacular registers constitutive of *chimurenga* are intended to explain the latter from the perspective of its originators and heirs. None of the literature on *chimurenga* grapples much with *chimurenga* as idea and laboratory. Instead, it is treated as a specific historical episode (the 1960s–1970s war) in which a few—politicians—liberated everyone else. Thus in these politicians' eyes, the ordinary people are ungrateful beneficiaries rather than combatants who fought using other weapons. How easy it is to forget that without these non-gun-wielding combatants the ammunition would have been damp and the gun would not have fired the colonizer out of power. But in the politicians' and guerrilla commanders' autobiographies, only *they* fought the war; the whole concept of who is a hero, who is compensated for their sacrifices in the war of liberation, is confined to political prisoners and guerrillas (Chung 2006; Tekere 2007; Bhebe 2004; Mhanda 2011; Mutambara 2014; Sadomba 2011).

By talking about *hondo yekuzvisunungura* (war of self-liberation), ordinary people insert themselves as agents in their own emancipation, reminding the elites about their own hefty sacrifices. Nobody was just *sitting there* while these heroic, selfless messiahs were busy fighting to liberate them. Thus, *hondo yekuzvisunungura* restores the idea of *chimurenga* as

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communal struggle involving the ancestral spirits, the people, the guerrillas, and a leadership deriving its legitimacy from the spirits. The politicians never came to liberate the people; they came to liberate power for themselves and fooled the people using the verbiage and spirit of *chimurenga* into believing the ends were as communal as the means. Perhaps that is why it was so easy for the politicians to betray the values their comrades died believing, and which perhaps they themselves at one point believed: values of communality in struggle, of *hunhu*, the philosophy that when one is hurting, everybody feels the pain, that the happiness of one amid a community in mourning is the antithesis of *chimurenga*.

From the perspective of the Rhodesians (white settlers of Rhodesia and their descendants), both as a legitimate anticolonial struggle and a historical genealogy *chimurenga* did not exist. The Rhodesians can't even accept that the black person has a brain, and our politicians' departure from the ethics of communal knowledge, purpose, and action that undergirded *chimurenga* has helped "prove" their point. To these Rhodesians the 1960s–1970s war was simply a "bush war"—a war in the bush. It was not even a civil conflict. Only whites were civil; blacks were "savages" that did not think, so they were "communist terrorists, or CTs," puppets of the Soviet Union and China. By recusing them from a capacity to think and calling nationalist guerrillas simply *magandanga* (bandits) or terrorists, the Rhodesians have reduced the entire project of *chimurenga* to terrorism (Smith 1997).

If the economy was booming, freedoms of expression, association, and assembly flourishing, and the communality of purpose that *chimurenga* promised in rhetoric the order of the day, the Rhodesians would be quite ashamed. Instead, they're saying, "We told you this whole *chimurenga* thing was hot air." Ordinary people are cast as victims—of colonial tyranny yesterday, black tyranny now (Chan 2003; Meredith 2002; Norman 2004, 2008; Hill 2003, 2005; Arnold and Wiener 2008). *Chimurenga* is trivialized as rhetoric that political elites and men with guns used to turn the ordinary people into ladders to power, often willingly, by force if needed (Kriger 1992).

This chapter is not a one-man mission to rescue *chimurenga* from ignominy but an enquiry into whether there is in *chimurenga* an idea or a philosophy worth rescuing to start with. For that rescue to be informative, *chimurenga* has to be liberated from its perversion by opportunists. In other words, *chimurenga* must be repositioned for enquiry as a site of creative work that did not start in 1896 or in the 1960s. Seen as such, it becomes an interesting space from which to make some critical interventions into the question of innovation. This chapter's terms of reference are therefore twofold: first, to explore *chimurenga* as laboratory (a site where creative work takes place), focusing on African modes of biological warfare; second, to place such innovation within the context of ancestral spirituality, which acts as an anchor and inspiration for all creativity.

Spiritually Guided Warfare

Recorded traditions say *vedzimbahwe* (the Shona's) ancestors came from *Guruhuswa* (the place of tall grass), referencing either the Nile valley (Egypt-Sudan) and later possibly the

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Niger-Congo region, or Tanzania (Hodza 1979, 217, 240–244; Diop 1974; M'Imanyara 1992). The exact location of *Guruhuswa* is still a matter of debate, but archeologists have carbon-dated pottery and other remnants and corroborated this evidence with linguistics, and they agree that this movement southward began around 1000 BCE. Two waves—one from the east (Tanzania), another from the Niger-Congo—arrived in *dzimbahwe* (lands of the Shona) around the fifth or sixth century CE and began establishing farming communities in areas like Ziwa and Gokomere, displacing the indigenous San inhabitants (Ehret and Posnansky 1982; Ehret 2002). The settlements emerged into a state system with prominent capitals or cities at Mapungubwe (eleventh to twelfth century), Dzimbahwe or Great Zimbabwe (thirteenth to fifteenth century), and Kame (1450–1683). Later prominent dynasties include vaRozvi (1684–1834), Mutapa (1430–1760), and many other subordinate or independent chiefdoms in between (Pikirayi 2001; Pwiti 1996; Mudenge 1988).

Murenga

The historical genealogies of vaRozvi in particular are explicit about the role of *Murenga* in guiding these immigrants from Guruhuswa to Dzimbahwe. They say a voice called *Tovela* "led them on their way, keeping them safe from dangerous places, feeding them. The voice could speak from any object," from grass, trees, infants, even stones. It was the voice of "the founding father of the clan," "the first person ever to be created," that guided every single group out of Guruhuswa in many different directions (Hodza 1979, 217).

When the Rozvi were famished and knelt under the tree of the ancestral spirits, pots of *sadza* (ground sorghum or millet meal), and calabashes of milk, and honey appeared from the ground. When enemies closed in on them, *Tovela* gave them medicines that rendered them invisible to their enemies. In time, *Tovela*, master-guide of the journey, on foot, of life, would come to be known by many names: as Mwari, god of all his people; *Manyusa*, the one who caused food to emerge from the ground; *Muwanikwa*, the one who was found; *Mutangakugara*, the first to exist; *Mupawose*, generous giver to all; *Samasimba*, owner and source of all power; *Chidzivachepo*, the original pool; and *Murenga*, in whose name the people shouted upon sighting an animal, "*Komborera, Murenga!*" ("Bless, Tall One/God!"), as they closed in for the kill. War was guided mobility. Nothing could be done without informing the ancestors first. *Vedzimbahwe* would place the ancestors in front just as they would in all journeys. After all, the soil the living walked on belonged to the ancestors (Shumba 1983, 84). All *masimba* (strength or power) came from the ancestors, who in turn asked for it from the *mhondoro* (clan spirits), and them from Mwari, on the living's behalf (Chinyowa 1983, 93).

In *vedzimbahwe*'s ritualized representation and enactment of *nzvimbo* (space) and *nguva* (time), there were moments when the human and animal realms were divisible and rigidly enforced and others when they were indivisible. The kingdom of humanity and that of animals had one sovereign, the *mhondoro*, who was at once a real lion, king of the forest, and the most senior ancestral spirit (*mudzimu*; plural *midzimu*), a deceased chief or clan founder who returned in spirit after death to look after the living. It was the *mhondoro* and the *mhondoro*

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alone who could intercede between *Mwari* (god) and the living. This senior spirit manifested and spoke to the living via his human medium, the *svikiro* (port of arrival), growling like a lion before and between words (Posselt 1935, 82). To see a real lion was, therefore, to see the clan spirit. Inevitably, the human domain (the village) and the animal domain (the forest) converged upon the *mhondoro*. *Vedzimbahwe* generally believed that *mhondoro* had power over all *zvisikwa* (creations)—humanity included. The leading nineteenth-century *mhondoro* of *vedzimbahwe*, Sekuru Chaminuka, was widely acclaimed to have "unlimited power over animals of all kinds. He could call the python into his hut—he could send out his natives [sic, African subjects] to catch a lion and the lion would not hurt them. If he sent them for any particular game, they would always bring it back" (Taberer 1905, 318). Along with Nehanda, Kaguvi, and Mukwati, Chaminuka was one of the key *mhondoro* of the 1896–1897 war.

Mbonga

As the keeper of *makona* (the clan's war medicines), *zimbuya guru* (great ancestress), popularly known as *mbonga* or *sviba*, was the most important person in the community after the chief. The *gona* (medicine horn) was usually an elephant tusk or kudu, duiker, or buffalo horn filled with medicines; hence, its other names were *runyanga* (horn) and *gona rezhou* (horn of elephant). The medicine was "a mixture of ground-nut oil, and herbs, and sometimes even limbs or internal organs of a human being" (Garbutt 1909, 537). The power of the chief and security of the whole *dzinza* (clan) was in the safety of the *gona* and its keeper, especially the winning or losing of wars. To consecrate a *mbonga*, a virgin princess of the clan was supposed to sleep with her brother, the chief, to arm and sustain the power of the *gona*. Incest was otherwise taboo and severely punishable; arming *gona* and consecrating *mbonga* was the exception (Hodza 1979, 139). Once installed, the *mbonga* took charge of the medicines of the *dzinza* and kept them out of harm's way. There were two taboos that she was to keep for the rest of her life: One, she was never to have sex, consensual or forced, ever again as long as she lived. Two, she was never to be captured or killed by the enemy, for it heralded the certain defeat—and demise—of the community.

The *mbonga* was the most prized target during war; kill, have intercourse with, or kidnap her and the entire security system became powerless, all weapons useless (Hodza 1979, 269n10). One of the most famed mbonga in the history of vaHota was called *vaNyemba*. It is said that she kept female black dogs that were, like her, not allowed to mate and that slept by her side. Nor were ordinary female dogs—that is, those that mated with the village's male canines—ever to enter the *mbonga*'s hut, lest they defile her (144n32). VaNyemba remained at home with the clan medicines, her dogs, and her attendants while her brothers went to war or to hunt. She beat her drum "to call and communicate with her clan, e.g. in answer to her brothers' hunting-call (*mupumhi*), to direct them to [their hunting] camp" (149n3) One day, vaHota's arch enemy, Gunguwo, chief of vaShawasha, attacked while the brothers were out hunting and overpowered and raped vaNyemba. Tradition says that by this act,

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Gunguwo "robbed her, and the clan medicines, of power to safeguard her brothers and to ensure their success in hunting" and war (149n3).

The *mbonga* played a critical role during migrations from *Guruhuswa*, especially when crossing big rivers like the Congo and Zambezi with their livestock. She would be in front and would strike the waters; when they parted, the people and the livestock would then cross (Hodza 1979, 253n7). The role of women in river crossing is clear in praises to the daughters of vaMhani. Their traditions say that when crossing the Zambezi, the clan's *mbonga*, Mwenda, struck the waters with her *shashiko* (a skin underskirt covering her loins, or loincloth) and they parted to allow the people and their livestock to cross south (242). VaMhani were not alone; vaNhohwe too paid homage to their *mbonga*, Nyamita, "*Mubvakure, makabuda nomumvura, nehwai dzikapera* [One who came from far away, who came out through the waters, losing all her sheep in the process]" (252, my translation). VaTsunga traditions say that when their own *mbonga*, Biri, struck the water's surface with her *shashiko*, it parted to form a *mukana* (pass) with two hills on either side, and the people walked forward on solid ground (273).

Sacred Animals

In the presence of the *mbonga*, *mhondoro*, and *Murenga*/*Mwari*, the animals—four legged, six legged, or slithering legless—cannot be seen simply as nature, fauna, or species. They have spiritual meaning and place in *vedzimbahwe*'s lives.

The *hungwe* or *chapungu* (bateleur eagle) was the bird of *Mwari*; its movements and sounds, when interpreted by mediums of the *mhondoro*—like Chaminuka—was *Mwari*'s pronouncement to his people. It is the bird that Shona sculptors carved, which archeologists subsequently found at *Dzimbahwe* (Great Zimbabwe). Those closely associated with it are the people of *Chasura* (the one who farts), foreigners in the domains of vaMhari of Chivi, in what is now Masvingo (Hodza 1979, 263). Laced with allusions to sex and male virility, theirs is one of the most seductive of Zimbabwean clan praises. *Chapungu* is different from an owl in that it defends life, whereas the owl is a witch's instrument that brings death and illness. When one sees *chapungu*, one sees *vasekuru* (grandfather), the ancestor. When *chapungu* circles above the home of a person struck by illness, the person recovers, a sign that the ancestors have refused to accept his spirit into *nyikadzimu* (the land of the departed ancestors) just yet (Nyevera 1983, 26, 29). In its mobilities and acoustics is a message—a wing-flap expressing happiness, a twisting somersault and flyaway warning of danger, or a sad, dejected shriek that portends one's death or that of family (Hodza 1979, 265n6). *Chapungu* usually appeared during—and was indeed the bird of—*chimurenga*. By its flight pattern, it warned warriors of danger or assured them, and it strengthened their resolve in combat.

Mbuyamuderere (praying mantis; literally grandmother in okra) was regarded as the great female ancestor or *muchembere* (grandmother) paying a visit to her *vazukuru* (grandchildren).

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Whoever spotted it took a small string or piece of cloth and placed it on top of the insect—an act of *kufukidza muchembere* (clothing grandmother), for this was the role society expected a well-groomed *muzukuru* (nephew/niece, grandson/granddaughter) to play. This insect mobility was a sign that the ancestors were ever-present and happy with the living (Nyevera 1983, 29).

Altogether, *chapungu*, *mhondoro*, and *mbuyamuderere* (along with *shato* the python) were carriers, embodiments, and messengers of the ancestral spirits. Theirs was not a faunal presence but a confirmation that the ancestors were present. Reconnoiters of the path ahead, repellants of dangers-in-waiting, the ancestors smoothed the path of all obstacles. To go alone into combat as mere mortals was *umbimbindoga* (reckless individualism); *chimurenga* was *mushandirapamwe* (communality of purpose) between *vari kumhepo* (those in the air; the deeper term for ancestors) and *venyama* (those of the flesh/mortals; Nyevera 1983, 19). Among other things, the ability to fight, to be a warrior, involved not only *zvidobi* (skills) or *ruzivo* or *zivo* (knowledge). It required a *shavé* (spirit; plural *mashavé*), specifically *shavé remangoromera* (fighting spirit), which did not substitute for training but activated skills into action; the one that *shavé* possessed fought like a lion (Mavhunga 2014, chaps. 1–2).

Zvombo Zvemurume

Of course, the ancestors protected those that took physical steps to protect themselves; they armed the weapons of those that were armed. Each man was supposed to have certain weapons, *zvombo zvemurume* (weapons of a man). The same weapons for home defense were the ones that each man took into battle as a warrior at the sanction of the headman, chief, or king. These weapons included two types of axes obtained from the *mhizha* (metalworker): the *dimuro* (chopper or cleaver) and the *demo* (felling axe), both used to cut wood, meat, and bones. To the *bira* (ceremonial dances of the ancestors), a man carried *mbadzo* (ceremonial dancing axe).

On journeys, women carried *tsomho* (small axes), while men took *ukano* (medium-sized axe), *pfumo* (spear), and *mubhadha* (staff). A man carried a large axe called *huhwa*, which was used mainly in elephant hunting. For combat, the *gano* (battle axe) and *ngwangwa* (large, broad-bladed axe) were considered most ideal (Hodza 1979, 354–355). A man could also carry or use, when times demanded, a *bakatwa* or *munòndó* (sword or bayonet), *ùtá* (bow), *museve* (arrow), *dáti* (quiver), *nhovo* (shield), *tsvimbo* (club), *mvaisi* (slingshot), *pfumo* (spear or assegai; plural *mapfumo*), *gano* (battle or hunting axe; plural *makano*), *muteyo* or *musungo* (snare, to trap or tie), *muchetura* (poison; literally, to cut; plural *michetura*), *hunza* (pit traps), *dhibhura* (gin trap for large animals; plural *dhibhura*), *riva* (gin trap for mice and birds; plural *mariva*), and *rusvingo* (fortification; plural, *svingo*). The making of these weapons has been described elsewhere and needs no further mention here (see, e.g., Mavhunga 2014, chap. 1; Daneel 1995, 50–53).

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Chimurenga as Laboratory: Chemical and Biological Weapons in *Dzimbahwe*?

One of the most interesting features of the precolonial *vedzimbahwe* concerns their tendency to build their homesteads on hilltops and to fight their enemies from the rocks. The arming of mountains was born out of thorough knowledge of the locale. Passes, caves, and highest points were known, with ambush positions carefully prepared in the camouflaged cliff overhangs overlooking the passes below. The caves were turned into bunkers, stashed with provisions to sustain the occupants for several moons if necessary. The high points were turned into sentinel positions to spot the enemy from afar. It was a common chidzimbahwe practice for chiefs or kings to settle their most trusted vassals—or cowards—on strategic hilltop settlements and near likely enemy approach routes to act as *nharirire* (sentinels).

The *nharirire* located on hilltops used three types of resources to signal approaching danger to the next hill: smoke during the day, a bonfire at night, and blowing a kudu horn where neither were visible. Upon sighting an enemy, a *nharirire* immediately blew his *hwamanda* (trumpet made out of kudu horn), alerting the one located on the next hill, who blew his to alert the one on the hill beyond, until entire communities near and far got the message, whereupon all men armed themselves and reported to their chief's court (if time allowed) or went straight into combat if the enemy was already nigh (Mtetwa 1976; Bhila 1978). We can therefore begin a conversation about a *chimurenga* communication signal system dating to long before contemporary modes of military signal equipment, codes, and procedures.

As able-bodied men jostled into combat positions among the hill stockades, the women, children, and elderly drove the cattle, goats, and other stock into the mountain passes or even caves. These stockades would have been prepared in peacetime with granaries of food and large pots of water stowed away to sustain people and livestock for long periods of siege. *Vedzimbahwe*'s security was community security, the division of labor paramount.

The communal spirit, the use of mountains and caves as infrastructures of defense, and the tactics that *vedzimbahwe*'s hostile neighbors the Ndebele called *ukutshona* (going under) were derived significantly from the *vedzimbahwe*'s observation of animals. Take *mbeva* (mouse), for example, the wild rodent that lives in *mapani* (valleys) and that *vedzimbahwe* trap, dig up, and eat. This widespread practice of *kuchera mbeva*—catching mice by digging up their *mwena* (burrows), which are very circuitous—served both as education about a potential defensive system and as a process of harvesting meat in the dry winter months. When digging, they were taken first to *garingiro* (sleeping area of the mice) where they saw *mambuze-mbuze* (bedding composed of fir, feathers, and other softitudes), and then *marishe* (granary), where mice stash pilferings from fields and forests. From this underground store, one or more *mbudo* (escape holes) lead to the surface; if one option to leave (getting out through the main entrance) fails, mice always have another. Before exercising that option, the mice proceed to *diziro*, another hole impregnable to diggers that mice dig and close (*kutsindira*; Mavhunga 2014; Mazarire 2005). A *dzimbahwe* proverb says

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that "*mbeva haicheri mwena usine mbudo*" ("a mouse does not dig its underground tunnels without an escape hole"). It always has an exit strategy. *Vedzimbahwe* also knew that mice prepare well in advance of the lean months ahead, hence, "*tsenzi inogara yadziya*" ("a cane rat rests only after all reeds are cut down"). The traditions of the people of Chihuri warn against the poverty of a strategy of "*kuhwanda mutumbi sembende inohwanda ichisiya muswe kunze*" ("hiding the body like the greybacked gerbil mouse that hides while leaving its tail outside"; Hodza 1979, 287). It will be discovered.

The second example of strategy learned from observation and developed out of a thorough understanding of animals in the process of utilizing them for food comes from *makurwe* (the edible type of crickets). *Gurwe* (singular) is a type of cricket that cuts down and feeds on young crops. In *dzimbahwe*, what Europeans called a *cricket* could be one of a lot of things with very different taxonomies. For instance, it could mean many different insects *vedzimbahwe* consider inedible, like *chikudyu* (also called *chikorokodzi* or *humbi*), a black cricket that usually lives near water bodies or in houses. The Nyanja have a proverb: "*Tsokonombwe anatha dziko ndikulumpha*" ("The *tsokonombwe* finished the earth by jumping"). This is in reference to the insect's impressive leap, which makes it an elusive quarry (Gray 1944, 110). *Ndororo*, *chinyamunjororo*, *njororo*, or *chikororo* is a type of cricket that lives on the edges of the pools and loves water; it can be seen especially when digging up *nyongorosi* (worms for fishing).

When people talk about crickets today, they are exclusively talking about the edible type, called *gurwe*, so-called because it cuts (*kugura*) crops and weeds and carries them underneath the soil to feed in its carefully but laboriously dug barrows. A *dzimbahwe* adage mocks the baboon and praises gurwe thus: "*Urombo hwamatede kunayiwa nemvura makurwe ari mumhatso*" ("The poverty of baboons, to be lashed by rain while the crickets are in the house"). Gurwe is also known as *jenere*, *huruze*, *gurene*, and *njurwe*. *Makurwe* start appearing a few days after the first summer rains—which allows them to hatch and start developing into *matumbuzenene* or *matumburufufu* (wingless crickets). A gurwe that has not yet grown wings is called *dumburufufu* or *dumbuzenene* (singular; *dumbu* [stomach]; *zenene* or *rufufu* [exposed]). It is called *dumbuzenene* because in its early stages it is similar to the real *dumbuzenene* (also called *shuwishuwi*, *tutwa*, *tagutapadare*, *chizen'enene*, *chidhenene*, *chidumbuzenene*, *dundira*, *dundiravazvere*, or *fufura*), an adult insect that looks like *gurwe*, with a big stomach and a hard head and abdomen.

There are two types of *makurwe* (plural). One is *chinyamutsavava* or *nyaruzanda* (literally *nyaru*, the owner or container of, and *zanda*, egg), or simply the female cricket. Its stomach is fat with eggs, and its outer wings are smooth black and cannot produce a shrill, vibrating, or rattling sound, called *kurira*. The other type is *mombe* (cattle; specifically, bull) or *gurwemombe* (bull cricket), signifying its male status. Its outer wings are rough and uneven, the source of kurira or *kukiriridza*, that shrill sound typifying early summer nights in Zimbabwe. One riddle states: "*Chikomana chinoridza ngoma nekuseri*" ("The fellow who beats the drum from behind"). My maternal ancestors, aNgoni of Malawi, observed and interacted with gurwemombe (which they call *nkhululu*) well, hence another riddle: "*Nyamata wanga woyimba*

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lingaka ndi kumbuyo" ("My servant who plays the kettle with its back"). Alternatively, they say: "*Anyamata a ku Mlanje aimbira ng'oma kumbuyo*" ("The boys from Mlanje [a district in Nyasaland] play the drum behind"). One riddle likens the small of the cricket's back to *lingaka*, a small drum slung around the neck and played, the other to *ng'oma*, the bigger, heavier drum that you must sit down to play. Usually, we know that *makurwe* are ripe for eating when *gurwemombe* starts *kukuriridza*; that is, when its wings are fully developed enough to be able to make that sound. As a rule, all immature makurwe (at the pre-*kukiriridza* stage) are considered inedible.

Gurwe digs and lives in a *mwena* (tunnel) in the ground, away from areas prone to waterlogging. *Chidé* or *mbudyo* (mbudo) is the second tunnel that *gurwe* and *mbeva* dig and seal, for use as an escape route when danger approaches from the main entrance. The other tunnel leads to *garingidya* (also called *garingizha* or *garingiro*), a big tunnel or bunker that the cricket makes and stashes food in. The soil gurwe excavates is called *duto* (mound). The ancestors' thorough knowledge of *kuchera mwena yemakurwe nembeva* (tunnels of crickets and mice) is shown in the following adage: "*mufaro mwena, kuchera unoguma*" ("happiness is a tunnel; when dug it comes to an end"). It is easy to tell whether the gurwe inside is mombe or nyaruzanda by just looking at the duto. *Gurwemombe* usually excavates a platform we call *chidumbati* (doorstep) to a depth that leaves its body flush with the ground, with its long twin antennae extended outward, so that it is not seen by predators on the ground, usually snakes, dogs, cats, mice, frogs, and owls. It uses its antennae and its eyes to detect any suspicious movement, to see without being seen; soldiers call this being in defilade position. At the first sign of trouble, it can dash inside and head toward *mbudyoo*. Hence the riddle: "*gomana rinoridza mumhanzi rakafedemara*" ("the big boy that plays music while stretching its wings"). The adage "*muchiri kumatutu isu tatova kuzvidé*" ("you are still at the entrance when we are already at the exit") is an acknowledgment of *vedzimbahwe*'s experience of being flummoxed by the cricket and mouse when digging for them. As a rule, *gurwemombe* always engages in *kukiriridza* with its head facing the entrance, never outward.

Mice and crickets were not unique as sources of valuable lessons to *vedzimbahwe*. From watching baboons post sentinels on treetops and hills while the rest of the troop devoured crops in people's fields and seeing their careful stalking of animal prey spoiled by a warning "bho-o ho-o!" bark from such *nharirire*, *vedzimbahwe* coined the proverb "*chati homu chareva*" ("that which has barked has said something"). Animals did not just make "noise" or "sound"; they communicated, spoke a language to each other. They managed risk to themselves through posting sentinels and calling out warnings. The ostrich, for example, used its height to warn unsuspecting springbuck of an approaching hunter, the buck passing on the message to other animals with its snorts and dartings-about (Millais 1895, 24, 81).

Other animals also "taught" *vedzimbahwe* to evade their enemies through camouflage. They did it in a subtle, subterfuge kind of way, behaving and looking opposite to what they were actually doing. Deception was the essence of the adage "*kusekerera nezino repamusoro*

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wakaruma repasi" ("to laugh with the upper tooth while hiding the lower one"). Indeed, "*zino irema, rinosekerera nemuvengi waro*" ("the tooth is a fool; it smiles even at its enemy"). This camouflage was one of two of the chameleon's potent weapons, immortalized in the adage "*kungwara kwerwavhi kusandura mavara arwo*" ("the cleverness of chameleon to change its colors" [and blend in with its surroundings]). Whereupon the chameleon became invisible to its prey, got behind a fly, remained motionless, then slowly advanced; when within reach, it darted out its tongue with astonishing speed. The fly vanished. There was no other teacher in the execution of speed and surprise in war, except perhaps *shato* (python), mesmerizing with its variegated body colors, getting closer all the time, then—*hla!*—the victim was gone.

Vedzimbahwe learned risk-management strategy from confrontations with a number of animals and immortalized them in language. From encounters with the leopard they learned the art of collective or communal responsibility and the consequences of individualism and selfishness. Tragedy taught them the folly of confronting the leopard or walking through leopard-infested areas alone. Out of this experience came the concept of *chirwirangwe* (fighting as one against the leopard). Its spirit is summarized in the *tsumo* (proverb) "*kuita muonerapamwe chuma chemuzukuru*" ("teamwork, the ethos of weaving the nephew or grandchild's beads") or simply *mushandirapamwe* (the ethos of working together). Even in a team, uncoordinated action was virtual suicide, for as vaMbari knew too well, "*mbada, ine mavara, isakananzva ichisiya rimwe vara, haiti iri idema, iri idzvuku. Inonanzva ose, mavara ayo*" ("the leopard, it has spots, it does not lick some and leave others, it does not say this is black, this one red, it licks all, for all are its spots"; Hodza 1979, 284).

If one person angered it, *ingwe* or *mbada* the leopard spared nobody, because all humans were the same; to defeat it, everyone had to own the problem before them. This antipathy toward selfish, individual actions with consequences to the community is born out in the *detembo* (poem) "Kutunhwa kwaDerere," in which the poet says: "*Chaipa chaipira sango. Chiramba wasara muno mumusha! Ngatiendei tindopera tose!*"; this is deep *chidzimbahwe* (chi-Shona) for "What is bad is bad for the forest. Let no one remain behind at home! Let us all go and perish to a man!" Translated into surface *chidzimbahwe*, it means "A danger for one endangers the whole. ... What harms one [person] harms the whole clan, both living and dead" (Hodza 1979, 344–346n10). *Shangwa* (famine), *magutsa* (years of plentiful harvest), *urwere* (affliction), *utano* (wellness), *ndufu* (deaths), *runyararo* (peace), *hondo* (war)—all these were partaken collectively (Nyevera 1983, 34).

Thus when somebody acting out of individualism got himself into trouble and rescue might gravely imperil the community, he was on his own. One such combat involved *chidembo* the skunk, which defended itself by sending its enemies into gas-dazed flight. If anyone ever deliberately picked a fight with chidembo, he or she had to deal with his or her problem and not call others to help, hence the adage: "*adenha chidembo ndechake*" ("if one angers the skunk it is his"). And another: "*chidembo hachivhiyirwe pane vanhu*" ("a skunk is not skinned among people").

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"Hot pursuit" wasn't always a wise military tactic; in fact, it could be a very stupid move. *Vedzimbahwe* knew too well that *chapinda kamwe hachiteverwi* (what has entered once and never returned cannot be followed). That is something that everybody who has encountered *mhungu* (black cobra) and its *nyamafingu* (banded cobra variant) knows all too well. I encountered it myself—during my boyhood, traversing Nyatsime River in Chihota from one *dziva* (pool) and *zambuko* (drift) to another, while fishing, while trapping birds with *hurimbo* (birdlime), and during *kufudza mombe* (cattle herding). I had countless confrontations with the snake. That is how I discovered that upon entering a hole, the extremely venomous snake immediately turns its head outward, ready to defend itself, as the rest of its body slithers down into the hole through sheer muscular contraction and expansion. For snakes, holes in the ground (normally abandoned clay caverns created by termites, openings between rocks, and hollows in thick tree trunks) are fortresses when fighting an enemy.

Of course, snakes are also a source of *muchetura* (poison; literally that which cuts to pieces); in fact, most poisons used in Southern Africa contained a snake-poison component. *Mhungu* and *chiva* (puff adder)—indeed, any large poisonous snake—was fair game for poison. Sometimes, the entire snake was pounded into a pulp and smeared onto arrows, but the most common formula was to cut the snake's head off, extract the poison glands, dry them, and pound them into dust. The powder was then placed either in an eggshell or the breastbone of an ostrich, the juice of the *mukonde* (euphorbia) then poured over it. The concoction was stirred and boiled into a thick brownish-red jelly, usually in summer when snakes were roaming about; it was kept in reserve for use during winter when the snakes were hibernating and impossible to find (Schapera 1925, 202–203).

To return to lessons, what is said of snakes is also true of *matsvinyu* (lizards; singular *dzvinyu*), as in the adage "*dzvinyu kuzambira zuva huona mwena*" ("when a lizard basks in the sun it is because it sees that a hole is nearby"). It was this tendency of the reptile to always forage within the proximity of its refuge that made it open to two interpretations. First, with regards to married women, the lizard was the source of a powerful charm to pacify philandering or violent husbands. The reptile was appropriately called *chipotanemadziro*, the one that never strays far from the walls of the house. Thus dzvinyu—or more appropriately, its tail—was cut off while the poor thing was alive, dried, and ground into a potent *mupfuhwira* (charm) to tame a troublesome husband (Hodza 1979, 19). For men, the custodians of community security against enemy attack, the lizard was a good teacher of defensive strategy; its lesson to them was never to fight the aggressor outside one's stockade and preprepared defensive position.

North toward the Zambezi River lay the lands of Neshangwe under Chief Chihunduro, whose political powers traditions say were based on "the war medicine and magic tail he possessed." Chihunduro was known to use "fierce bees [he kept] in a calabash," which he unleashed upon his enemies, vaRozvi, the dominant power in *dzimbahwe*, before the Ndebele arrived. Every time he was embarking on a military expedition, Chihunduro "consulted the tail, which stood erect if success were in store" and lay prostrate if the

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campaign might result in defeat. Both the powers of the tail and the bees were disarmed when his wife, given to him by his vaRozvi rivals as a peace-building gesture, returned to her people and disclosed her husband's secrets (Posselt 1935, 141).

VaTsunga praise their clan as "*vanofamba namago panyanga*" ("those who travel around with wasps on their horns"; Hodza 1979, 275). *Mago* (wasps; singular *igo*) were not just charms of war, but actual wasps carried in a horn. They would already be riled by all the bumpiness of journeying, and vaTsunga cranked the venomous insects' ire even higher by shaking up their containers. Then they offloaded them among their enemies. I know how it feels; I cannot recall how many times mago stung me. There are three types of wasps in Zimbabwe, each known according to its size and habitat. *Magomombe* (cattle wasps) are very big, brown, elongated ones and are usually found near cattle pens. *Magodanda* (log wasps) are shorter, thicker, and gray in color and are found underneath hanging branches, especially dead ones. The third type is *magombudzi* (tiny goat wasps), which hardly sting, and when they do, cause little harm. VaTsunga hardly would have bothered with the last type.

Then there was *chinyavada* the scorpion. Also called *mhani*, this black variety is a delicacy for *gudo* the baboon, despite it knowing all about the insect's painful, even deadly, sting. The particular type found in the Hwedza to Nyanga-Mutare (east) area and south into the lowveld stretching from Mwenezi into Mozambique toward the coast is usually the *mhanimhani* (ordinary short scorpions; Hodza 1979, 198n31). It was in homage to the presence of this insect that the eastern mountain range of *Chimhanimhani* (short scorpion), corrupted into Chimanimani by British colonizers, is named. *Vedzimbahwe* observed the baboon patriarch to have all rights to the scorpion, "just as the Shona chief, *muridzi wapasi* [owner of the ground/land], has a right to the pangolin" or the ground tusk (Hodza 1979, 199n44). The scorpion was a weapon in war, a six-legged biochemical weapon. Lamentations to vaMhani's ancestors speak of scorpions being thrown at people as a *chitsinga* (debilitating spell): "*Chitsinga chamandindindi chinopisa chinovava chinoshunya chinoregerera waruma nyimo kwete mufemi, chinomonyorotsa pfungwa nendangariro, chinovava senduru yakarungwa mhiripiri*" ("A tough spell that burns and itches and pinches, that also lets go of one who has bitten the cowpea [died], not the one who still breathes, that churns the mind and memory, sour and hot like bile marinated with peppers"; Chirombe 1983, 285).

The use of insects to deliberately spread affliction, to win wars, and as instruments for torturing captives to extract intelligence has been documented in other parts of the world (Ahuja 2011; Hamblin 2010, 2013; McNeill 2010). Indeed, so prominent is the role of insects in the history of warfare that Jeffrey Lockwood called them "six-legged soldiers." At different times in history, the Romans, the Vietcong, Japanese, North Koreans, and indigenous Americans alike have used such arthropods as flies, scorpions, potato bugs, *nyuchi* (bees), and hornets to decide battles (Lockwood 2011, 127–149). Historian Lansiné Kaba tells the story of the army of Songhai, the most powerful West African kingdom of its time, which in 1591 tactically drew its Moroccan enemies into the mosquito- and tsetse-infested swamps of

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Tondibi on the Niger River. There it held the invaders off while the insects worked on them and their horses. The casualties were staggering (Kaba 1981, 466).

Equally stunning are examples from recent history. During the Second World War, the British authorities sensationally accused locusts of aiding and abating their enemy, Adolf Hitler and the Germans. Following the outbreak of hostilities, the British administrators charged that the locusts had "joined the Nazis as enemies of humanity," justifying "campaigns" to be launched against them "from North Africa to India." The biggest "offensive" against this Nazi "ally" was in Kenya from 1943 to 1947. It involved "13 drives, the 4th involving 4,000 troops, 33,000 labourers, 750 cars, and 3,000 tons of poison bait in one operation" (Uvarov 1951, 67).

Discussion: Some Implications for the Concept of Innovation

Therefore, *chimurenga* or *Murenga*'s way of fighting becomes a laboratory—a space replete with experimentation, application of ideas to practice, and practice generative of new ideas. *Vedzimbahwe* are not simply receiving knowledge from animals; they are engaged in a cognitive and productive process. Observation, experience, encounter, and testing the (in)efficacy of various techniques. Trial and error might involve observing birds feeding on fruits, meaning the latter were not poisonous, and so people tried them. Animals going about their everyday lives became subjects of experiment, the equivalent of lab animals or test herds—guinea pigs—except without people touching them. Dissection of carcasses and understanding their anatomy occurred during the hunt or when slaughtering livestock, specifically during the killing, skinning, cutting, and distribution of meat, each part given to a person according to his or her position within the extended family or clan.

To that extent, one finds in *chimurenga* the communalism, universalism, disinterestedness, originality, and skepticism (CUDOS) that Robert Merton discusses ([1942] 1973, 268). Another author whose ideas seem applicable is Ludwig Fleck ([1935] 1979) and his notion of thought collectives; he argued that "scientific facts" were active constructions shaped by sociopsychological attitudes shared by collective cognitive entities. Am I saying, as Paul Feyerabend (1975) did, that there is no such thing as scientific method, that "anything goes"? No. I am saying it can't be the case that Western science is the only one that has a method and that all others must be false because the Western one is correct. If *dzimbahwe* knowledge is false, it must be false on its own terms or on neutral grounds, not on the terms of other traditions of knowledge production. I might ask if a neutral ground exists—but I digress. My point was to show that proverbs and tales demonstrate clearly that these were not just casual or one-off observations by individuals.

Knowledge individualized was dead. *Vedzimbahwe* did not write on paper; orality, language, practice, and communality are what brought and kept information alive from generation to generation. Communality also became the *mhenenguro* (peer review) process through which *wongororo* (observations) and *mashoko* or *mazwi* (words; deep *chidzimbahwe* for

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statements) were interrogated, corroborated, and canonized as *tsomé* or *ruzivo* (knowledge) or *chokwadi* (truth). Proverbs, tales, riddles, and other forms of *dzimbahwe* communication media were all outcomes of communal verifications and disproof over long periods of time. Experiences in real life, outcomes of encounters—some individual, others group experiences—were shared through conversations at *nzvimbo dzedzidziso* (sites of education) like *padare* (men's fireplace; this also means community court), *pachoto* (women's fireplace), *kuhuni* (firewood gathering), *kuvhima* (hunting), and so on. *Vadzidzisi vetsika, tsomé, namagariro echinyakare* (teachers of customs, knowledge, and ways of living of the olden times) are what I have called the *professoriate of indigenous knowledge* in *Transient Workspaces* (Mavhunga 2014).

The sites, practices, and ethics of communal action and responsibility offer two interesting contrasts. First, Western scientific practices and capitalist society, which celebrate and reward individualism, even selfishness (Popper [1934] 1992, 102), became even more pronounced after passage of the Bay-Dole Act (1980) in the United States , the act that shaped the international patent system. Second, with respect to Soviet, North Korean, Chinese, and Cuban versions of socialism and communism, which abhor the individual and celebrate the collective, but nonetheless turn to collective action (socialism, communism) to address contradictions arising out of an individualistic and materialistic system: capitalism. Both the Western and Soviet system start with the individual and move toward the collective (class), whereas *vedzimbahwe* start from community or the communal, hence the sayings: "A person is not a person without others" and "It takes a village to raise a child."

Vedzimbahwe exhibited humility to learn from animals big and small. To them, animals were no mere fauna or species but indivisible from the human. The lion, bird, or praying mantis was the vehicle in which the ancestor traveled, the medium and form through which the ancestor spoke. Here was human intelligence thoroughly dependent upon the presence of and interaction with other animals. In *vedzimbahwe*'s experience we see the animal as an intellectual being, not just imbued with but imparting reason. In other words, *vedzimbahwe* showed the humility to be students to the animal. Seeing animals as agents or teachers and people as students or respondents to them shows the communality of *zvisikwa zvaMwari* (god's creations).

Did *vedzimbahwe* derive *kutora mhuka sevanhu* (treating animals as people; anthropomorphism in Western parlance) from the animals themselves, or did they map human characteristics specific to their society (or *dzimbahwe* anthropomorphism, if one may) onto animals? It seems the answer is both. In any case, respect for the animal as a person or humanizing other creations was much better than *kubata vamwe vanhu semhuka* (treating other human beings as animals)—the worst form of inhumanity in *chidzimbahwe*—and the project of European colonialism was exactly that! This suggests that it is impossible to reckon with the human or animal separate from each other. What happened when animals were taken away through arbitrary European colonial laws creating game reserves in twentieth-century Rhodesia? Perhaps that's why *vedzimbahwe*'s descendants have produced no new animal-based vocabularies ever since. A whole conversation between people and animals died.

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Encounters with animals were teachable moments in another sense: They served as moments for the acquisition through experience of empirical evidence that *vedzimbahwe* later abstracted into a general statement regarding the animal—and most tsumo (proverbs) and *zvirahwe* (riddles) were general statements about specific animal species. A single encounter did not constitute general knowledge; various encounters did. They may be seen as spaces in which statements about the behavior of an animal were generated and/or confirmed. The more the encounters and the more similar the experience of many people in different places and situations, the more a general statement was made about the animal's behavior. Then, through similes, proverbs, and tales, the animal's behavior and encounters with it were turned into general statements—theory.

The discussion of snake, scorpion, and other poisons invites us to begin a serious conversation on African modes of chemistry. In *Transient Workspaces* (Mavhunga 2014), I deal with plant poisons among *vedzimbahwe* and *maHlengwe*. In an ongoing research project titled "African Chemistry," I extend the enquiry beyond animal- and plant-based poisons to pyrotechnology. If fire-making, pottery, metalworking, and explosive-making force us to reckon with African *mhando* (modes), *pfungwa* (ideas), and *maitirwo* (practices) of African physics, then plant- and animal-based poisons take African chemistry toward the realm of African biology. The poisons affect *uropi* (brain) as matter and *pfungwa* (mind, thinking, or thought), *mutyairi wehupenyu* (the driver of life); they affect *mwoyo* (heart), the command center of *hupenyu* (life); they also induce *kugwamba kweropa* (clotting of blood) in *tsinga* (veins); and they affect *muzongozozo* or *muzongoza* (nerve). The observation and capture of animals, the extraction and production of poisons, the reasoning behind and deployment of poisons as weapons, and their effects when seen within a calculus of strategic-tactical advantage speaks to the serious intellectual work of African biochemical warfare.

The work of weaponizing wasps, bees, scorpions, ants, and snakes through poison production and consolidation into *zvombo* (weaponry; singular *chombo*) illustrates a rich history and philosophy of *ruzivo* (knowledge), *nzira* (ways, means), and *kusika* (creativity). The greatest *musiki* (creator—and thus innovator) is *Murenga* himself, and *chimurenga*, the ways of *Murenga*, comes to mean the ways of the creator—that is, *innovation*. I do not mean innovation in the narrowed sense of technological and commercial innovation that Western theorists have confined it to as a consequence of their context-specific historical experiences (Godin 2009; Nye 1997, 2003; Long 2001; Hilaire-Perez 2000). Nor is technology itself purely reduced to artifacts (L. Marx 2010), so that innovation becomes merely summoning technology and science to "the relief of the human condition" (Zagorin 2001, 390). Charms like *chipotanemadziro* (loiter around the house) can no longer be dismissed as myths based on built laboratory or bench science standards alone. They are outcomes of *kudzamisa pfungwa* (deep thinking or intellectual engagement) on *kufamba nemaitiro emhuka* (the mobilities and behaviors of animals) and *zvakunoreva* (their meanings). One cannot end with meanings. When a whole society believes that animal limbs mixed with other ingredients make potent

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medicines and that such medicines can be deployed to affect human behavior, it provides an opportunity to begin an enquiry into African neuroscience.

Vedzimbahwe's keen observation of animals big and small in their habitats demonstrates that knowledge is not only factual outcomes of experiments or something which when subjected to Western science lab methods today yields "facts" as defined by Western science. *Ruzivo* or *ruzivo rwechokwadi* (true knowledge) according to *vedzimbahwe* depends upon communality as a peer review mechanism to reveal what a community determines to be *chokwadi* (true).

Fewer people knew of what we now call *asymmetrical warfare* than *vedzimbahwe*. Mountains could be weapons; a praying mantis was a teacher in military strategy; but war was always the last recourse. First, there was living in peace. One peace-building strategy was for a chief to give his daughter away in marriage to his fiercest rival; she became the bridge of peace between two warring communities. Simultaneously, this daughter given away in marriage, consenting or not, became a weapon to disarm powerful rivals through intimacy, as bait, or *soft power*, women being seen among *vedzimbahwe* as gentle in heart and flesh and men hard. Being gentle was an attribute of a good woman and a useless man.

What then to make of the spiritual in a narrative of *chimurenga* as laboratory? We need to do more than what colonial writers used to do—namely, expunge the spiritual detail and subject *vedzimbahwe*'s so-called myths, fables, and black magic to Western laboratory units and standards of measure. Whatever "science" existed within such material had to be proven in Western-built laboratory experiments using procedures from Western scientific traditions. Chidzimbahwe protocols or *mitemo* (laws) under which this *ruzivo* had been created through *kunzvera* (close reading) of the surroundings or creations were now dismissed. The reason? The spiritual (faith) had no place in (the production of) facts.

As is now clear, it is impossible to account for *vedzimbahwe*'s close reading of animals without confronting the meanings of *Murenga/Tovela* and *mbonga*. Both resemble the experiences of the Israelites from bondage in Egypt to Canaan—specifically, the famous parting of the waters as the armies of Pharaoh closed in. The only difference is that Moses uses his *tsvimbo* (staff), whereas *mbonga* beat the waters with her *shashiko* (loincloth). In Israelites' journeying, there is a spiritual presence in the interactions between the people and their surroundings, especially animals. What then should be said of insects, birds, snakes, and lions in the context of *vedzimbahwe*'s abiding beliefs in ancestral spirits and *Murenga* as guide and inspiration in life, and *mbonga* as armorer of all weaponry, protector of all security?

Mbonga also presents a conundrum: a sister forced into incest and rendered a lifelong celibate to ensure her brother's—and the dynasty's—ascension to and remaining in power. She is at once a victim of male power and the most powerful woman in *dzimbahwe*. Knowing she is safe or has been captured determines the warrior's mentality going into combat. Mbonga forces us to confront the relationship between spirituality and psychology—indeed, neuroscience—from a deep African perspective. In her, we see the use of sex as a weapon, a

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solemn act, a spiritual procedure to arm weapons, to lend power to medicines—an entire adult life lived as a weapon of one's brother and community. Not just any sex—sexual intercourse that's supposed to be *chipini* (abomination) because of *miko* (taboos) against it, but made an exception for royalty. Armed through intercourse, disarmed through intercourse, the one by a brother, the other by the community's enemies. Mbonga forces us to confront the relationship between *zvinechekuita nemuviri* (matters of the body, or the bio) and *nzira dzekuita nadzo zvinhu* (ways and means of doing things, or the technological) from deep dzimbahwe *pfungwa sezviito* (thought as practice).

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3
The Metalworker, the Potter, and the Pre-European African "Laboratory"

Shadreck Chirikure

Knowledge production has always played a pivotal role in the development of societies throughout time, regardless of place (Delanty 2001; Chirikure 2015). However, in the last two decades, an avalanche of information technology has transformed the world into a knowledge-based society, characterized by knowledge sharing using different digital platforms. In this information and knowledge age, the laboratory occupies a colossal space, one that shapes and determines each and every aspect of society. According to the Merriam-Webster Online dictionary (www.merriam-webster.com), a *laboratory* is a place equipped for experimental enquiry in a science; it is a place providing opportunity for experimentation, observation, or practice in a field of study. This definition vividly paints the image of a modern laboratory as a built environment in which scientists wear lab coats and operate sophisticated equipment to conduct science and produce knowledge.

The "success" of the global west in transforming the rest of the world (more intensely) from the nineteenth century onward has entrenched science and the university as dominant and, in most Western cases, as the only way of knowing (Delanty 2001; Hall 2009). Indeed, science and laboratories lie at the heart of the relationship between the academy and capitalism. As such, top universities and global corporations invest trillions of dollars of funding into knowledge production through laboratory-based research and development. For example, laboratories at universities such as Harvard, Cambridge, and Oxford, as well as those of global corporate giants such as Apple, are multibillion dollar facilities for which individual revenue and expenditure dwarfs by stunningly astronomical proportions the budgets of many third-world countries, such as Zimbabwe, Botswana, Malawi, and more. Such is the dominance of the laboratory and science, two of the most iconic attributes of the modern (Western) knowledge-production system.

The extension of the view that knowledge is science often contradicts the thinking in most non-Western societies that knowledge is culture (Delanty 2001). If knowledge is culture, then it can be produced wherever humanity works and performs quotidian and technical tasks.

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In Africa, as elsewhere in previously colonized parts of the globe, Western science and the Western laboratory were introduced at colonization. After its establishment, colonialism in Africa endured for more than half a century or more and was responsible for transforming the nature of knowledge production in the former colonies. Science and the Western laboratory entered Africa at the expense of local knowledge that was not only marginalized but also challenged for being unscientific. In postcolonial Africa, knowledge production and science and technology continued on the foundations established during the colonial period: those of science, the academy, and the laboratory (Hall 2009). The "success" of Western science and technology has often been accompanied by the erroneous and arrogant view that indigenous African sites of work and ways of knowing were inferior and unworthy of any detailed studies. As Holl (2000, 6) argued: "Throughout the colonial period, sub-Saharan Africa was considered a backward continent on the receiving end of technological innovations." For example, technologies such as precolonial metal and pottery production, pursuits that were heavily set in rituals and symbolism, were viewed as retarded and derivative in origin (Chirikure 2005, 2015). In fact, such a perception was an inheritance from European stereotypical views dating back to the early nineteenth century, if not before. Then, most Westerners believed that because of a different system of knowing and producing science, Africa had no history, no past, no technology, and no innovations (Killick 2015). Consequently, African societies and technologies such as iron working were thought to be in a "deep and perpetual slumber" without any advancement (Goody 1971).

Contra these views, this chapter argues that precolonial Africa—like many other previously colonized regions in Asia, Latin America, and elsewhere—had sites of work and knowledge production at which innovations, inventions, and experimentation took place. Such sites of work were deeply wrapped up in the view that knowledge is culture. Therefore, they were not built environments or laboratories in the modern or Western sense, but they nevertheless played an important role in knowledge production that networked the world from early on (Chirikure 2015). Using the example of precolonial metallurgy and pottery making, this chapter showcases various innovations and instances of experimentation that took place in disparate parts of the African continent. The sites of work and knowledge production were often embedded in, and were eschewed for being in, the living space and the natural world. If we use the word *laboratory* to describe these processes, we find that these sites of knowledge production were transient and never fixed on one point (Mavhunga 2014). Furthermore, they were characterized by a great deal of fluidity involving not just spatial organization but also technical and symbolic practices. Just because such technology and how it was generated and applied differed from that of the West does not in any way suggest that it did not exist or that it must be ignored. As Hall (2009) eloquently expressed it, the modern academy and science should find ways of embracing other knowledge systems for the good of the world.

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Laboratories without Buildings: Sites of Indigenous Metal Production in Precolonial Africa

Metallurgy is one of the most important technologies of all time, heavily embedded both in science and in culture and history. However, its origins may not have had anything to do with science as we know it today. According to Smith (1981), the beginning of metallurgy in Eurasia circa 5000 BCE was all about colors and tonality of metals concerned. About ten thousand years before the present, some communities in the Middle East and adjacent regions were using colorful ores of copper such as malachite to manufacture bodily ornaments such as beads. Although the technology of metal production changed over time and was punctuated by context-specific innovations, it was only in the last three hundred years of Western history that this technology became heavily set in science. According to Hansen (1986), until the medieval period, ritual and symbolism were embedded in European technology such that the rejection of cultural beliefs as superstition only became common during the Enlightenment period. Even when it became a universal way of knowing in the West, science blended concepts from many regions such as the Middle East. This demonstrates that as a syncretic way of knowing, science should not marginalize other ways of knowing, but must rather incorporate them or be incorporated by them. According to Delanty (2001), the establishment of the view that knowledge is science in the West witnessed the importance of the academy as an important knowledge-production space in which the laboratory played an essential role. The laboratory, housed in custom-built buildings, became the principal site at which scientific facts and ideas were developed and validated before their application in sites of work such as industries.

In contrast to this, both the development of ideas and the execution of those ideas in Africa took place at sites of work where men and women often collaborated to produce metal. The evolution of indigenous African metallurgy, a millennia-old technology, provides a platform on which we can ruminate on these ideas and expose the fact that precolonial Africa had "laboratories" that combined experimentation with innovation to produce products and ideas in its own spatial, historical, and technological context. The technology of primary iron production in precolonial Africa was through the *bloomery* process, in which ores were reduced to metal in clay-built, charcoal-fueled furnaces to produce solid metal and waste products such as slag (Miller and Killick 2004; see figure 3.1). Despite the diversity of ores, the temperatures for reducing the ores of iron ranged between 1,100 and 1,200 degrees Celsius. According to Rehren et al. (2007), one of the most widely held misconceptions is that system-driven parameters dictated that human beings could do little to either influence or modify furnace operating systems, such that the product (metal) and waste materials (slag) were compositionally identical regardless of time and place. The available evidence from many corners of Africa shows that the bloomery technology was neither practiced in custom-made buildings nor laboratories (Cline 1937), but it was characterized by a great deal of experimentation, innovation, and adaptation, often by trial and error, which bequeathed a staggeringly rich inheritance of technological diversity.

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Figure 3.1
Late nineteenth-century, low-shaft furnace from Nyanga, Eastern Zimbabwe. The makers and operators of this furnace are unknown. The furnace is decorated with female breasts and a waist belt *mutimwi*, worn by women to enhance their fertility. Despite these symbolic beliefs, the smelting process followed scientific principles such as reduction and thermodynamics, demonstrating that technology and culture were inseparable.
Source: Author.

One of the major innovations associated with indigenous African metallurgy relates to the use of multiple furnace types across different regions and time spans. Three major furnace types—bowl, low-shaft, and high-shaft natural draft furnaces—were all still being used in the nineteenth and early twentieth centuries (Cline 1937; van der Merwe 1980; Kense 1985). *Bowl furnaces* consisted of a semicircular depression in the ground lined with refractory materials (Chirikure, Burrett, and Haimann 2009). A variant of this type had a superimposed short shaft aimed at providing high volumes and better draft when compared to the ordinary bowl type (Miller and van der Merwe 1994). The *low-shaft furnace* type stood between one and 1.5 meters above the ground; the diameter at the base varied (Kense 1985). The shaft acted as the combustion chamber and was insulating enough to promote heat retention during smelting. Further distinctions have been made of these low-shaft furnaces, between those that had a provision for slag tapping and those without this feature (van der Merwe 1980). Finally, *high-shaft natural draft furnaces* stood between 1.5 and four meters above the ground. In contrast to the bowl and low-shaft varieties that were operated by forced draft, these huge furnaces were universally powered by natural draft (van der Merwe 1980; Kense 1985; Chirikure, Burnett, and Heimann 2009).

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Although patchy, archeological research in many parts of Africa exposed a rough progression in the manner in which furnace types were developed as a consequence of experimentation and or improvisation. The available evidence suggests that the earliest furnace types used in West, Central, and East Africa were the low-shaft and bowl furnaces. Natural draft furnaces, believed to be a unique African invention, only appeared after the middle of the first millennium CE (Robion-Brunner, Surneels, and Perret 2013). The chronological evolution of these very big furnaces in different parts of Africa is not well understood. In southern Africa, the earliest evidence seems to be the Tswapong Hills (Botswana) furnaces, which are characterized by tuyeres fused in multiples. Tswapong furnaces belong to a cultural period known as Zhizo, which flourished between 800 and 1200 CE (Huffman 2007). Dating back to the mid-fifteenth century CE, the Darwendale natural draft furnace excavated by Prendergast (1975) just outside Harare in Zimbabwe is one of the most-cited examples of similar furnace types in the region. Ndoro (1994) also identified natural draft furnaces through the presence of multiply fused tuyeres at Chigaramboni near Great Zimbabwe, but the furnaces have yet to be dated.

Although the archeological distribution of natural draft furnaces is not clear, ethnographically they are restricted to West, Central, and East Africa. Here, they are associated with different production contexts, from the small scale to the large scale. In the Bassar region of Togo, the tall natural draft furnaces (2 to 4 m in size) were used to exploit high-grade hematite ores in large-scale production geared toward the external market (de Barros 2013). Yet in Malawi and adjacent regions, natural draft furnaces (1.5 to 2.5 m in size) were used to smelt very low-grade laterite ores in a two-stage process (Killick 1990). The smelting in Malawian natural draft furnaces produced slag and an iron-rich sintered matrix, which was further smelted in low-shaft furnaces to produce forgeable iron. As such, natural draft furnaces were a technological innovation developed for different environments and scales of production—those with rich ores geared for the external market (Bassar, Togo) and those with low-grade types best for comparatively smaller scales (Phoka, Malawi)—demonstrating innovation, improvisation, and experimentation at work. All this was taking place, depending on context, at sites of work inside and outside villages, as determined by the location of resources and by cultural and other considerations.

Besides furnace types, another major innovation associated with iron smelting in precolonial Africa relates to slag tapping—the continuous removal of slag during reduction (van der Merwe 1980). Before the development of slag tapping, smelters allowed slag to solidify inside furnaces or in pits at the bottom of the furnaces. Once the furnace bottom was full, smelting could not proceed. Slag tapping provided a way of draining slag from the furnace as it formed to achieve more output (Cradock 1995). African smelters invented this innovation and applied it to all the known furnace types: bowl, low shaft, and natural draft. In the Democratic Republic of Congo, slag-tapping bowl furnaces were used (Ackerman et al. 1999), and Malawian natural draft furnaces also employed slag tapping. In the Nsukka region of Nigeria, there is a clear progression from non-slag-tapping low-shaft furnaces to slag-tapping low-shaft

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furnaces in the Early (500 BCE–500 CE) and Late (500 CE–1700 CE) Iron Ages of the area (Okafor 1993). This shows that once invented techniques could be adapted through innovation, improvisation, and/or experimentation to suit various furnace types.

A great deal of improvisation, likely through trial and error, was also employed in the use of various furnace types to smelt ores of different metals. For example, while iron was widely smelted in the three furnace types worked in precolonial Africa, tin and copper were mostly smelted in bowl and low-shaft furnaces, employing tapping and non-slag-tapping technologies. So far, there is only one documented but short-lived case of copper smelting in natural draft furnaces, at Kansanshi in Zambia (Bisson 2000). It appears that the experiment did not work, because the smelting of copper in natural draft furnaces was never attempted again at the site or elsewhere. There are technical reasons; smelting copper in natural draft furnaces reduces more iron, creating a low-utility iron-copper alloy tantamount to wasted effort (Chirikure and Bandama 2014; Craddock and Meeks 1987). If this experiment had worked, we would have seen more copper smelting in natural draft furnaces at the site well into the historical period. However, unlike iron, copper was smelted in crucibles often resembling normal pottery (Bisson 2000). The ethnographic survey conducted by Cline (1937) revealed that across Africa, neighboring groups had differing furnace types and smelting recipes and distant communities often possessed similar furnace types, creating a confusing mix. Undoubtedly, this indicates that different communities innovated and experimented with varying recipes that have bequeathed an amazing array of technological styles and repertoires. Most of these sites were open-air places with no custom-made buildings or fancy testing equipment.

The variability that we see in furnace types was also accompanied by that of methods used to feed air into the furnaces during smelting. Air was essential for sustaining reduction. Ethnographically, two methods were used to introduce air into furnaces: pumping bellows or drawing air naturally using the principle of convection (Rehder 2000). Two types of bellows, bag and pot types, have been recorded historically and ethnographically in Africa (Cline 1937). *Bag bellows* essentially consisted of a sack of softened animal skin; one end had a big vent to admit cool air, while the opposite end was connected to a nozzle that channeled the air into the furnace (Chirikure, Burrett, and Heimann 2009). Often, the base of the bellows and the nozzle were fastened to supports, making it easy to orient the blast into the combustion zone of the furnace. In general, the intake valve was created by a pair of wooden planks sewn across the opposite sides of the large opening, with loops on them to hold the fingers and thumbs of the bellows operator. Historical and ethnographic evidence has shown that bag bellows were routinely utilized in pairs. The bellows operator was required to maintain the rhythm—when one was up, the other one was down (Dewey 1990).

Pot or drum bellows consisted of a pot or wooden cylinder with a loose animal skin diaphragm covering the top (Chirikure, Burrett, and Heimann 2009). Typically, wooden sticks were fastened to the center of the diaphragm. Upward thrusts of the sticks drew air into the cylinder, while downward thrusts expelled the air into the nozzles. In the case of wood-carved

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bellows, nozzles were an integrated part of the structure. Bellow nozzles were pointed into the funnel of a tuyere, a measure designed to prevent the intake phase from sucking luminescent charcoal into the bellows.

It has been proposed that the volume of air generated by pot and bag bellows was almost equal, but a lot depended on the skill of the operator (Merkel 1996; Chirikure, Burrett, and Heimann 2009). There is no clearly discernible pattern in the distribution of bag and pot bellows types in Africa. In general, drum or pot bellows and their variants are mainly distributed in West and Central Africa, with a minor presence in Africa south of the Zambezi. In contrast, bag bellows have a universal presence across Africa but seem to be the dominant type used in parts of South Africa and Zimbabwe. Sometimes, one group used both types of bellows, while others used only one type (Cline 1937). Also, it was common for neighboring groups to use different types of bellows, indicating that the decision to use one type over another could have been a result of cultural preferences. Because bag bellows are made of perishable materials, they rarely survive in the archeological record. Pot cylinders occasionally have been found in situ with tuyeres that connected them to furnaces; for example, archeologists working at Meroe in the Sudan excavated a furnace with blow pipes and pot cylinders in their original position in 500 CE context (Shinnie 1985). On the whole, the poor survival rate of the archeological signatures for bellows implies that it is difficult to figure out the historical precedence of various types. What seems to be clear is that there was a great deal of improvisation and technological cross-borrowing within and between groups, and this probably explains the complex patterning of bellow types across Africa.

The production of metal took place in varying contexts that ranged from outside residential areas to within homesteads. In many cases, metal-working precincts were situated in close proximity to resources such as ore, water, and clay. A consideration of the available knowledge shows that most smelting precincts were not associated with any buildings. However, as we have seen, these open-air places were sites of experimentation and improvisation. As such, precolonial metallurgy was a user-defined science that contrasts significantly with laboratory-defined Western science. New furnaces were developed and introduced to exploit various ores in these open-air sites. This example demonstrates that laboratories in the modern sense are neither the only places for knowledge production nor the only places in which science can be conducted.

Primary metal production was associated with symbolism and rituals that were part of the technological and cultural repertoire. Ethnographically, indigenous iron smelting is metaphorically associated with human reproduction and copulation. Furnaces are considered to be symbolic of women who are impregnated by male smelters to produce a symbolic child—iron. This belief is attested to in furnace designs such as the one shown in figure 3.1. The tuyeres that supplied air into the furnaces are known as *nyengo* in Shona (Ellert 1984). Often, sexual intercourse is known as *kunyengana*, making it explicit—particularly when considered in light of the female anatomy of the furnace—that iron smelting was symbolically viewed as a metaphor for human reproduction. Often, smelters in African societies were required to

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practice sexual abstinence when smelting, because it was believed that adultery with their real wives would result in failed smelting. Fertility symbolism also pervaded indigenous iron production in India. Tripathi (2013) argues that among some Indian communities, iron smelting was metaphorically equated with human reproduction. This demonstrates that in non-Western worlds, science and technology were deeply embedded in society and culture.

Homesteads as Laboratories for Pottery Production in Africa

One of the most important technologies frequently used in pre- and postcolonial Africa is pottery production, which was essential in making utilitarian and ceremonial containers. According to the American Society for Testing and Materials (ASTM), *pottery* refers to "all fired ceramic wares that contain clay when formed." Pottery is made by forming a clay body into objects of a required shape and heating them to high temperatures, thereby removing all the water from the clay to precipitate reactions that increase the strength of the objects. Like the introduction of metallurgy, the beginning of pottery production in Africa remains poorly known, but it is possible that the oldest pottery in sub-Saharan Africa dates to circa 9500 BCE in Central Mali. It seems that pottery production evolved separately in multiple contexts, although not much work has been invested into researching this, which is not surprising given that culture history–oriented ceramic typology still remains the dominant way to study ceramics in much of Africa. Consequently, most of what we know about pottery production and use in the subcontinent comes from ethnography. It is also clear that African archeology has not been decolonized; it still religiously follows methodologies developed in the West without calibration to suit the local context.

In contrast to metallurgy, which was the domain of men, pottery making and ownership was mostly intimately associated with women (Lindahl and Matenga 1996). As a consequence, pottery making in much of Africa took place inside houses. The knowledge of pottery making was often transmitted from mother to daughter, although some potters could learn the craft on their own through experimentation. Ethnographically, participant observation indicated that the clay from the quarries was processed to remove unwanted materials, and often temper was added to increase the clay's plasticity. Alternatively, clay from different sources was mixed to achieve the desired strength (Lindahl and Matenga 1996). The right clay was mixed with water to make a fine paste, which was molded to produce pots of various sizes and types (figure 3.2). Once dry, the pots were fired in pits or open areas using different types of fuel, such as wood or dung.

As an exclusively female craft, men were not allowed near clay sources, nor was their presence allowed during pottery firing. Violation of these taboos would result in pots cracking. Although seemingly simple, pottery production required a detailed knowledge of raw materials, particularly their behavior when wet and dry. As such, constant experimentation and innovation was the order of the day. Archaeological analyses of the mineralogy and chemical composition of archeological and ethnographic pottery reveal that potters prospected for

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Figure 3.2
Photograph of a woman making pottery in her house in Giyani, South Africa. The photograph was taken by archaeologists for illustrative purposes to aid in learning in class the way in which archaeological ceramics were made. Because of the lack of decolonization alluded to previously, effort only was invested in recording processes and techniques such that, like in most colonial books, the name of the potter was not recorded, which anonymized this knowledge producer. This practice of not naming African knowledge producers was common in the colonial period and still continues in some ethnoarchaeological works.
Source: F. Bandama (with the permission of the author).

suitable clays that contained heat-resistant minerals such as kaolin and alumina (Chirikure, Hall, and Rehren 2015). However, because archeology and *ethnoarchaeological* (a very problematic, stigmatizing word) knowledge production have not been sufficiently decolonized, local names used for various clays, various tempers, and decorations that appear on African pots are mostly unrecorded. It appears that most archeological effort is aimed at describing processes from the universalizing view of the West, and in so doing it fails to critically open insights into African technosocial experiences.

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Ethnographic work demonstrated that different types of pots were used for a variety of purposes (Ndoro 1996). Studies of pottery made by the Karanga, a subgroup of the Shona people mainly distributed in Southern Zimbabwe, revealed that use and function were correlated. Bowls known as *mbiya* were used for serving food, whereas constricted pots called *hadyana* were used for cooking relish. Shouldered pots, *shambakodzi*, were used for cooking *sadza*. Bigger pots, *rongo*, were used for fetching water, while *gambe*, the biggest pot type, was used for beer storage. Other pot types include *hodzeko*, used for storing milk, and *pfuko*, used for keeping liquids such as *mahewu*. When broken, pots were recycled as *chainga*, used for roasting maize and ground nuts. The designs on some of these pots mirrored those on iron-smelting furnaces and other items of material culture, suggesting that fertility symbolism was an integral feature of African quotidian and technical practice. Various pots could be used in multiple contexts, ranging from the mundane to the ritual and technical domains. Using ceramics from the Gokomere Tunnel site, Ndoro (1996) convincingly demonstrated that some of the Karanga pot shapes can be identified in archeological assemblages dating back to the early first millennium CE. A look at the archeology indicates the presence of pots that were used for multiple purposes, from storage to cooking and serving food. Some pots also were used in ritual circumstances. However, in Southern African archeology, local ceramic names and uses are hardly considered at all, resulting in the presentation of archeological pottery only as an analytical aid and not as a knowledge-production outcome that holds a reservoir of cultural and technical information.

Archaeologically, not many pottery production places have been recorded in sub-Saharan Africa, largely because potting took place inside houses. The firing of pottery did not take place in special kilns but rather in open fires, as well as in shallow pits. It is therefore pertinent to raise the following question: Are the houses where pottery making took place laboratories, given that they were sites of knowledge production and experimentation? This is pertinent because ethnographic practice indicates that some types of clays, when used on their own, made pots that cracked upon drying due to lack of temper. Often, this situation was remedied by the addition of nonplastic materials known as temper or by mixing two different clays with different properties. The potters understood these issues and made technological interventions such as changing clay sources to achieve the best results. Thus, there was continuous innovation and adaptation across the process, from the house to the raw material source. These places and spaces where experimentation and production take place can hardly be regarded as laboratories in the modern sense, but they are associated with knowledge creating, sharing, and dissemination.

As with metallurgy, the production of pottery was associated with rituals, beliefs, and taboos. Among groups such as the Shona, pottery was the weapon and domain of women (Aschwanden 1982). Men were not permitted at clay quarries, just as they were forbidden from pottery-firing localities. Menstruating women too were barred from clay sources. Taboos were enforced in some cases, but in others they were relaxed, particularly in the context of use. Pottery made by women was used by men for eating, whereas metal made by men was

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used by women for agriculture and digging clay used for making pots. These cross-craft overlaps in taboos as well as in use make technologies such as metallurgy and pottery important for understanding gender relations in material production and use.

Discussion: Should Western Concepts Always Have African Equivalents?

In this chapter, an argument was made that although the Western world views knowledge as science produced by the academy, the non-Western world views knowledge as culture (Delanty 2001; Hall 2009). The non-Western view of knowledge is more holistic: It considers nonwalled sites of work such as the fields of Mexico, irrigation schemes in Papua New Guinea, and, as we have seen from the preceding case studies, sites of metallurgy and pottery making in Africa to be *laboratories* in which sustainable, sociotechnical solutions are generated.

In Mexico, farmers recognized that various weed species are beneficial because they can be harvested for medicinal purposes and can be used as stock feed. Therefore, they knew that not every weed has a harmful effect. Mexican farmers continuously experimented in the fields, utilizing their indigenous knowledge in a way that promotes sustainable agricultural practices (Chambers and Gillespie 2000). Contra this, laboratories in the Western sense are buildings dedicated to scientists' work; they are equipped with high-tech equipment essential for experimentation, production, and validation of facts and new knowledge. This model of science and laboratories as the keys to technological progress is contradicted by the philosophy of knowledge production in the non-Western world, which in the case of African metallurgy and pottery making was often more communal than proprietary.

This philosophical difference may also be attributed to capitalism and its obsession with an almost unlimited desire to accumulate wealth, with the corollary that laboratories and production units are geared toward mass production. For the technologies of today to serve billions of people on earth, they have to be produced at the requisite level. It therefore is not surprising that when companies such as Google started, they were developed in the garage but then considerably increased in stature, building gigantic laboratories to become the global giants that they are today. When these generalities are considered in light of indigenous African technological practices, several fundamental points emerge. Because they were designed to effectively service comparatively smaller populations, indigenous African and other non-Western "laboratories" often were sited in spaces and places commensurate with serving smaller communities. Fields, homesteads, and houses were essential for various knowledge-production activities that were sustainably utilized. Therefore, although science has given humanity the capacity to produce on a large scale, it has also introduced challenges associated with sustainability, an integral factor for non-Western societies because of the holistic manner in which they treat knowledge, nature, and culture.

However, because of the integrated link between technology, nature, and culture, there was no need to make massive investments into infrastructure such as laboratories. In any case, technological acts were socially embedded, underpinning the relationship between

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men and women, specialists and nonspecialists, and the young and the old. Specialization was also embedded within other aspects of society, unlike in the modern world in which laboratories specialize in different things to the extent that often there is no integration with negative consequences to the environment.

Warnier and Fowler (1979) discuss the large-scale iron production among the Babungo of Cameroon, which took place in the context of increased demographic pressure. The sites of production became bigger and bigger, but still they remained fundamentally different from modern concepts of a laboratory. For example, symbolism, rituals, and taboos mentioned previously were part and parcel of this iron-production enterprise, but in modern laboratories they are rejected for being "irrational." In any case, a flashback to Europe's past indicates more or less the same phenomena, whereby production was mostly outside houses and also was heavily set in ritual (Hansen 1986). This should not be surprising, because the dominance of science and laboratories is only a recent phenomenon (seventeenth and eighteenth centuries) that was in part fueled by industrialization and capitalism (Delanty 2001). As such, the laboratory is not the only way of producing knowledge; neither is it always the most effective, given that it promotes specialization, which disintegrates the parts making up an integrated whole. Rather, it presents a question of context and scale: Science and technology are innovations precipitated by the acquisitive desires of capitalists, the need to meet growing demand from growing populations and growing competition for increasingly scarce resources. As such, modern laboratories are ideologically designed for a completely different philosophical position compared to that of precolonial Africa.

The close consideration of precolonial metal and pottery production presented previously animates discussion on several points of interest about African sites of work and sites of knowledge production. The first point to consider is that precolonial Africa had many sites of knowledge production, such as smelting sites, which were often networked with raw material sources, homesteads, and other places as society met its quotidian needs. Depending on how one looks at it, the beginning of pottery and metal production is one of the earliest scientific innovations in Africa's recent past. As for metallurgy, a number of innovations in furnace types and methods of provisioning air into the furnaces evolved at various places of work in various regions. The Mafa smelting furnaces of Cameroon could produce cast iron using a technology known traditionally only to produce soft iron (van der Merwe 1980). Elsewhere in the world, cast iron was produced using blast furnaces in Chinese antiquity (Wagner 2008), and in Europe it was associated with the early beginnings of the industrial revolution. The Phoka smelters of Malawi were confronted with geology deficient in high-grade iron ores. In response to this, they developed a two-stage technology that initially beneficiated the low-grade laterite ores to create an iron-rich matrix, which was further processed in low-shaft furnaces to produce iron. In modern-day South Africa, smelters developed a technology of adding sand during smelting to reduce titanium-rich magnetite ores, which cannot be processed in modern blast furnaces (Killick and Miller 2014). All of these innovations demonstrate mastery within a local context of the furnace-operating conditions that

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we explain today using principles from chemistry and thermodynamic theory. Indigenous Africans may not have had this knowledge, but, as far as products are concerned (cast iron and steel), they equaled what we can achieve today in modern laboratories and industries.

Reaching beyond pottery production and metallurgy to consider architecture, it becomes clear that various technological practices in precolonial Africa were integrated with each other. For example, although rituals excluded women from sites of metal smelting, the furnace itself was symbolically a woman, such that women were conceptually present during smelting. Furthermore, men were not permitted near pottery production sites, some of which were in the household, a shared space between men and women. Taboos had to be relaxed in the homestead context for men and women to coexist, however. Shona pottery was made by women just as the plastering of houses (*kudzura*) and making of earthen floors (*kurovera*) were. In some cases, women used the labor of men. The decorations on houses often included female anatomical features such as breasts that were also present on furnaces and pottery, reflecting that fertility symbolism pervaded the Shona worldview; each sociotechnocultural activity was a miniature version of the general ideas that pervaded society. However, in today's context, some of these interlinkages are now being replaced by the modern: Builders who are mostly male now construct houses and plaster and floor them using cement. This destroys cross-gender overlaps in labor provisioning and marginalizes some of the ideas associated with households in indigenous African societies.

Although comparatively little archeological work has been performed with sites of African indigenous pottery production as a consequence of the lack of surviving evidence, it is clear that innovations and experimentation took place. It must be stated that most indigenous African communities did not have written literacy, so we do not know their names. Also, archeologists rarely use linguistic information to attempt to address this gap. In keeping with established (during the colonial period) archeological practice, African archeologists use the modern names of places to refer to these precolonial people whose names are unknown. The material culture used by such communities also is identified using modern place names. For example, pottery decorated with distinctive incisions was first found at Eiland near Tzaneen in northern South Africa. However, the pottery was found at many sites distributed across northern South Africa and adjacent regions of northeastern Botswana and southwestern Zimbabwe. Some of the communities making this Eiland pottery at Rooiberg in northern South Africa between 1200 and 1300 CE deliberately added ground broken potsherds (grog) to the clay as temper, which improved the performance characteristics of their pots (Bandama, Hall, and Chirikure 2015). Grog has a beneficial effect in that it allows for better heat absorption. This technological solution of adding ground pottery as temper may have been cultural as well. This is reinforced by the fact that pottery that comes after Eiland, known as Madikwe by archeologists, has no such temper (Bandama, Hall, and Chirikure 2015).

The picture that exists archeologically is that throughout the two thousand–year history of pottery production and use, different indigenous groups made different types of pottery. Even today, the pottery made by the Venda people of South Africa is different from that used

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by the Zulu and other groups in sub-Saharan Africa. However, archeology is not equipped to distinguish similar ceramics made by different groups of people. Be that as it may, that different pottery types were used and continue to be used by neighboring and related groups in the last two thousand years of sub-Saharan history is a powerful indicator of local innovation, improvisation, and/or experimentation. In all these cases, the site of knowledge production was in the case of pottery the domestic space where people lived; this is where experimentation and improvisation took place. Similarly, with primary metal production, experimentation and innovation took place at smelting sites, some located inside villages but others outside (Chirikure 2015). Here, master smelters could impart knowledge to apprentices, who later modified existing knowledge within conventions to innovate through trial and error experimentation. Therefore, indigenous potters and metal producers constantly innovated, but clearly their sites of work are different from our conception of a *laboratory* in the modern sense of the word.

Although innovation, experimentation, and improvisation were permanent features of indigenous pyrotechnologies in Africa, the demographic context was intimately linked to the scale of production. For the very low-population densities characteristic of much of precolonial Africa, the available technologies and ways of knowing were appropriate. Pottery and metal production were seasonal activities primarily handled outside of the normal agricultural cycle. In contexts with high demand for metal, the organization of production was reorganized to suit this demand. For example, although iron working among many Shona groups in Zimbabwe was seasonal, the Njanja of Zimbabwe maintained a year-round iron industry to meet demand from neighboring groups and the Portuguese in Sena, Mozambique (Mackenzie 1975; Chirikure 2006). This industry located in the heart of the village was only interrupted by colonialism in the late nineteenth century. Similarly, Shaka Zulu employed full-time metalworkers, who smelted iron and made spears throughout the year using very small bowl furnaces that reduced the time required to produce metal (Maggs 1992).

What is clear from this information is that the activities that take place in today's laboratory—experimentation, trial and error, and much more—took place at African sites of work such as smelting precincts and homesteads where pots were made. In fact, the laboratory was always with the people, be it in the agricultural fields of Mexico, the stone construction at Great Zimbabwe, or the irrigation in Papua New Guinea. These sites of work in precolonial Africa produced commodities that promoted local and regional interaction. Indeed, Southern African iron, gold, and copper were exported to the Indian Ocean rim region via the East African littoral (Summers 1969). Similarly, West African metal found itself in the Islamic world via the trans-Saharan trade. Moving to another category of material culture, pottery was also traded between and within groups, resulting in the imitation, improvisation, and admixture of styles that we see archeologically (Pikirayi 2007). One of the most important points to note about precolonial Africa is that no patenting was practiced, such that knowledge was communally owned. As such, inventors, innovators, and improvisers worked not just for themselves but also for the community at large.

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Therefore, the African laboratory if we can talk of one was communally oriented but produced goods and commodities that satisfied not just local but also external needs. It is therefore a great misconception to think that the laboratory as conceptualized in a Western sense brought civilization, progress, and light to illuminate what was then a primitive, regressing, and Dark Continent Africa and a non-Western world (Mavhunga 2014). The truth is that for much of Africa's history most people did not even care that the built laboratory existed. Instead, they had their own sites of experimentation and application of knowledge that fulfilled their needs. As such, the European-established laboratory is the dominant laboratory today, but it displaced preexisting local ones. In a few areas where pottery is still being produced and scrap metal is forged in villages, the urban-based laboratory exists in complement with these rural and local ones.

Conclusion: Toward a Decolonized African Science, Technology, and Innovation Practice

"There are many ways to skin a cat," says the cliché. Modern laboratories and science are one of the many interventions that humanity made and continues to make in order to meet routine necessities. The example of two pyrotechnologies, metallurgy and pottery, that were central to precolonial societies in Africa shows that innovations, improvisation, and experimentation were hallmarks of this non-Western system. If *laboratory* refers to any place where knowledge is produced through experimentation, improvisation, and adaptation, then the many open-air sites and houses where metals were smelted and pots were made are *laboratories* that sustained Africa's growth. This holistic manner in which knowledge was produced was also a distinguishing feature of precolonial Mexican, Indian, and Papua New Guinean communities. If crop fields, workshops, or places of work are laboratories, then in their own context the non-Western parts of the globe such as Africa had their own unique ways of knowing, improving existing knowledge and applying it to solve different problems at hand in a sustainable and integrated way. The only problem is that we do not know much about technologies that sustained precolonial Africa, with many mistaking the absence of knowledge in the present for an absence of knowledge in the deeper past. African archeology requires a major program of decolonizing theory and practice to place African ways of doing things, African terminologies, and African ways of knowing in the center of academic enquiry. The language of African archeology is largely Western, with no attempt to include more local concepts and ways of describing and understanding things. It is the locally specific that is lost in this universalizing way of learning about laboratories, technology, and innovation. Archaeologists must work with linguists and other specialists in African cultures to produce African-centered knowledges. Therefore, just as modern science and laboratories are suited to some modern contexts, African ways of knowing are and were suited to their own context, if only we invest more time in decolonizing and studying them.

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4
Plants of Bondage, Limbo Plants, and Liberation Flora: Diasporic Reflections for STS in Africa and Africa in STS

Geri Augusto

Sou eu aquele que plantou
Os canaviais e cafezais
E os regou com suor e sangue ...
E nem a morte terá força
Para me fazer calar.[1]

—Carlos de Assumpção (1958), cited in de Camargo, Colina, and Rodrigues 1986, 53; italics in original

Whatever rocky soil she landed on, she turned into a garden.

—Alice Walker [1972] 1983, 271

I scattered seed enough to plant the land
in rows from Canada to Mexico
but for my reaping only what the hand
can hold at once is all that I can show.

—Arna Bontemps [1963] 2009, 95

African creativities are found in African mobilities.

—Chakanetsa Mavhunga

For some time, I have been interested in that often violent but also generative intersection of knowledge about plants among European colonizers, the indigenous peoples of Africa and the Americas, and black people enslaved in Europe's vast colonies, particularly on plantations in what the incoming occupiers at first deemed the "New World" (Augusto 2007, 2009). The literature about medico-botanical, agricultural, and other natural knowledge of indigenous peoples and of enslaved Africans and their descendants is growing, and these topics are now looked at through a variety of approaches, from anthropology to archeology, from environment to medicine. However, this literature is still not an integral part of a truly globalized history of science and technology, one which takes the cognitively just position that human societies and knowledges are coeval without having to be judged commensurate or that genealogies of contemporary technological imagination and innovation are also to be found in Africa and its diasporas. That different history of science and technology, emphasizing

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what was creative, inventive, and put together differently—assembled or reassembled—by enslaved Africans and their earliest descendants, needs to be more intentionally generated and more explicitly interrogated.

I will take a recent project of *making*, the creation of an object and of a specific space—a seed assemblage and a small symbolic slave garden, both of which I recently researched and designed for Brown University's Center for the Study of Slavery and Justice (CSSJ)—as point of departure, a way of *visualizing* and remembering African diasporic botanical systems of knowledge and belief. I will use that work as a mediator in a conversation about knowledge and innovation from an angle less often considered, from the optic of persons once deemed not human. I will describe, discuss, and speculate about some of the spaces in which botanical knowledge from Africa was transplanted, reimagined, reassembled—alone or together with other knowledge—reinvented, or reworked in new spaces and contexts by enslaved persons and suggest that these spaces might also be productive locations for thinking about innovation.[2] With that aim in mind, I will posit some metaphorical plant categories. In doing so, I am informed by (but will not extensively rehearse here) a burgeoning set of archives about colonial sciences, indigenous knowledges, the material culture of plantations and of slavery, slave gardens, and maroon settlements (*quilombos* or *palenques* as they are known in Brazil and other parts of Latin America), as well as by Africana visual arts and literature. The latter references start right from the poetic epigrams with which this chapter begins, invoking what the enslaved wrought of fertile fields, rocky soil, and seeds with blood, ingenuity, and toil.

I am also impelled by the not easily describable pull of my ancestors and the experience of living in Angola (from whence came so many of the captive Africans brought to the Americas), as well as working in Southern Africa and Brazil. In these spaces, one African and one diasporic, I have taken many an *epistemic walk* through farms and botanical gardens first established under colonialism or its successor regimes.[3] Most recently, my thoughts have been stimulated by some of the conversations already being generated by the assemblage and the CSSJ garden. Those exercises in collectively thinking with a tangible object and a symbolic inscription in the ground, somewhat to my surprise, have taken off in multiple directions. Some have found them a touchstone for talking about the role of Native American crops and herbs in the early New England colonies. Others have been prompted to reflect on food heritage globally, on African and diasporic environmental ideas, on the relation between textiles and slavery, on the aesthetics of enslaved women's headscarves, and of course about future directions in the historiography of slavery. But for the purposes of this chapter, my broad arguments will be limited to two. I will assert that the ways in which enslaved Africans and their descendants created, adapted, used, and *thought* about plant knowledge in the Americas, under the most coercive and traumatic of conditions, constitutes one possible alternative genealogy for innovation and for technological imagination. I will also argue, mainly by demonstration of just a few of the possibilities for doing so, that at the intersection of STS and the interdisciplinary field of Africana studies might lie some critical resources for

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reframing the knowledge of enslaved Africans and their earliest descendants in the diaspora as both ideas and practice, and we might arrive at novel ways to think about histories of technology that come from within a unique historical experience.

The terrains I will consider as spaces of knowledge and innovation in this chapter are threefold: first, those where enslaved Africans (and earlier also indigenous peoples) brought not just their muscles but also their expertise to the work of cultivating, harvesting, and processing crops that I will call *plants of bondage*, those plantations and estates throughout the "New World" which generated vast wealth in the Americas and Europe. The conceptual term itself is almost self-explanatory, once one stops to think of its direct implication. It is common knowledge that bondswomen and men produced cotton, sugar, tobacco, indigo, rice, cacao, and coffee. As the incorrigible runaway and abolitionist Henry Bibb, editor of the newspaper *Voice of the Fugitive*, put it in an 1852 letter:

> Now with all candour in answer to this proslavery logic, let me ask who is it that takes care of the slave holders and their families? Who is it that clears up the forest, cultivates the Land, manages the stock, husbands the grain, and prepares it for the table? Who is it that digs from the cotton, sugar, and rice fields the means with which to build southern Cities, Steam boats, School houses and churches? ... and yet they or their children are not permitted to enjoy any of the benefits of these Institutions. ... Oh! tell me not then Sir, that a man is happier and better off in a state of chattel bondage than in a state of freedom. (Blassingame [1977] 2002, 52)

What needs registering here is that bound up in perpetual servitude were knowledge and skills that sometimes resulted in new technological combinations for production of those plants of bondage. An exemplary and well-documented case is that of the tidal (mangrove) rice-growing system, the innovative creation of which on the West African coast dates back to the eleventh century (Fields-Black 2008). Centuries later, on Georgia's coastal plain, one environmental historian notes: "Planters and their [West African] slaves molded the lands ... that had proved useless to the first colonists into formidable units of production" (Stewart [1996] 2002, 89). Carney and Rosomoff (2009, 153) famously go further, calling rice cultivation in the Carolinas "not only the transfer of African seed to the colony, but the simultaneous migration of an entire African agricultural and processing technology by enslaved African rice growers." Future new histories on the other plants of bondage may disclose similar contributions by the enslaved, not just to the transformation of botanical landscapes in the Americas, but also to the agricultural technologies involved in doing so.[4]

The second space to which I wish to direct attention, in connection with mobile creativity and reinvention, is that of the life-saving and in some cases astonishingly productive gardens in the interstices of the plantation—the dooryards and small plots of the slave quarters and the provision grounds at the margins of the masters' estates, which Carney and Rosomoff (2009) have most aptly termed "botanical gardens of the dispossessed." Here, the enslaved raised what I will call *limbo plants*. These were a mix of plants carried over from Africa, including okra, black-eyed or cow peas, and sesame, among others; plants re-encountered in the

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Americas after having already been adopted in Africa, such as cassava (mandioca) and corn (maize); and plants indigenous to the New World, nutritional or medicinal, and often at the same time simply aesthetically pleasing. More will be said of this category of limbo plants ahead.

Lastly, I limn those plants I have elsewhere called *liberation flora* (Augusto 2009), cultivated and developed in the free territory of maroon (*quilombola*, *palenque*) communities using the plant knowledge (especially agronomic) traditions and cultural templates of the enslaved, as well as those borrowed from the indigenous inhabitants of the region and from the plantation experience—the plants the enslaved could at last grow solely for their *own* provisioning, trade, and well-being as one concrete practice of self-liberation and resistance in landscapes they could refashion and control.

Clearly, these conceptual categories are not iron-clad; plants of bondage, such as sugar cane or rice, could and did show up as liberation flora in new free spaces, and limbo plants (e.g., tobacco or vegetables) likewise transgressed when relocated or sold for the slaves' own purposes.[5] Nor are they, as metaphoric notions, intended to erase now-indispensable scientific botanical names and categories, and the units of environmental analysis that are hegemonic in much of global knowledge practice. Rather, these concepts are used here to spark new ways of thinking about innovation, drawing from spaces where creativity was mobile and mutable by the hardest necessity and nonetheless connected to social life, human imagination, spirituality, and the practices of (or at least aspiration to) freedom, even among those who have been called "socially dead" (Patterson 1982).

In doing so, I take Mavhunga's (2014, 8) working definition of innovation: "The act of introducing something new, be it a method or a thing, either from scratch or from outside," including the capacities of ordinary people "to import and deploy things coming from outside" and assign the "incoming thing" new meanings and purposes. However, I am working with a particular case here, one in which captive Africans *themselves* were "incoming" and "imported." That requires us to think from a different directionality. Those captives carried their creativities internally across *kalunga*, the sea dividing the living from the dead in Kongo cosmology—mobility in the utmost sense. Besides this notion of mobile creativity, I also want to work here with a very old-fashioned understanding of invention—that is, Usher's notion of it as the emergence of new things from an "act of insight" which results from "cumulative synthesis" (Ruttan 1959, 600–601)—and suggest that it is a concept that, alongside innovation, might help further illuminate the plant knowledge created and practiced by enslaved Africans and their descendants. Invention, in this view, involves not just the intangible results of imagination, but also invention of processes and technologies in a *recombination of existing knowledges*. I argue that such recombination or cumulative synthesis has been one of the hallmarks of African creativity in the Americas, including with respect to the cultivation of plants in contexts rife with violence and threat, but also with the very human imperative to recreate, resist, and survive. We might conclude that trauma and resistance have *also* been the mothers of invention.

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In the sections that follow, I will use the artworks I referred to previously that I created for CSSJ to help suggest some of the ways in which the plant knowledge of the enslaved might generate reconsiderations about innovation, drawing on the humanities (anthropology, history, art history, literature, cultural studies) and environmental studies for illumination. In my broader project, I am exploring further some of the newer research on the unique and underheralded contribution of key African plants to plantation economies, life, and culture in the Americas; recent studies of slave gardens and plots and other material culture on a few well-known, iconic US slave plantation sites; examples of plant knowledge that resulted from the interchange among enslaved Africans and the First Nations (Native American cultures) throughout the New World; and the historical records of plant knowledge in maroon/quilombola communities, particularly those analyzed in great depth under a veritable explosion of new interdisciplinary Brazilian scholarship on slavery. In this chapter, there is only space to gesture at this ongoing, larger work. Throughout, gardens are a focal point, plants and the contexts of their cultivation the epistemic object, and rethinking genealogies and notions of innovation from an African and Afro-descendant perspective the broad intent.

Performative Research and Visualized Knowledge: Cabinets, Gardens, and Patches

It will be useful to explicate briefly the assemblage constructed in an antique box for storing and displaying seeds and the symbolic slave garden. These were performative research, intended "not only to describe phenomena but also to enact possibilities" by attending to the ontological implications of *doing* and not just writing (Fisher et al. 2015). I wanted both the assemblage and garden to communicate differently from how a text might and to invite coproduction afterwards of the ideas and symbolic meanings they initially inscribe. To a great extent, this is what African and diasporic oral and artistic traditions do—a reverberating, imaginative, but space-effective flexibility that I would suggest is itself a facet of innovation and worth reclaiming as such.

Both artworks-in-the-making were deliberately thought of, as well, in apposition and opposition to two of the most important techniques for visualizing and taking back to Europe scientific knowledge and diverse artifacts obtained by virtue of expansion into Asia, Africa, and the New World: (1) *Wunderkammern* or curiosity cabinets and (2) botanical gardens. By the seventeenth century, Cook (1996) notes, all world-class universities in Europe boasted both of these among their essential mechanisms for knowledge production (see figures 4.1 and 4.2). Bleichmar (2006) argues in her work on Spanish imperial botanical expeditions to the Americas and the eighteenth-century botanical art of Jose Mutis that curiosity cabinets were a "conscious decision to present a pictorial alternative based on both scientific and artistic criteria."

Botanical gardens and "dry" herbaria were extensively used in the studies of nature conducted by Europe's "armchair botanists," who, as Whitaker (1996), Schiebinger (2004),

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Figure 4.1a
Natural history museum of Ferrante Imperato of Naples.
Source: Ferrante Imperato, *Dell'Historia Naturale* (Naples, 1599).

and others point out, often conducted their visual examinations indoors in the comfort of private studies. Those gardens and herbaria, having incorporated plants detached from indigenous knowledge and contexts, generated countless dissertations and learned articles back in Europe (Augusto 2007). Moreover, some of the most famous collections of traveling scientists and physicians who returned home to consolidate fortunes accrued in the colonies not only graced their own private cabinets but also became the foundations of great museum collections of natural history. One of the best-known cases in point is that of the physician Hans Sloane's Jamaica collection, which became the core of the British Museum (Delbourgo 2010; Quilley and Kriz 2003).[6] Cook (2007) ties all these ways to represent and circulate knowledge explicitly to the rise of new sciences in Europe, which were actually, he argues, produced by hosts of people all over the globe, thanks to the new global European trading companies.

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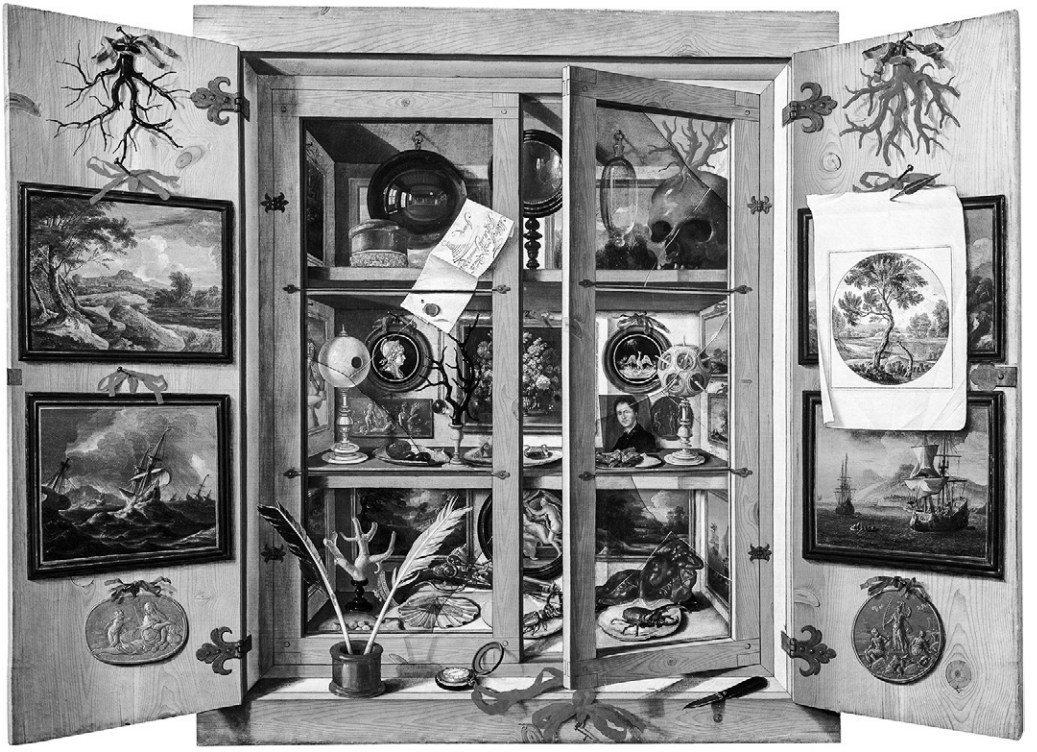

Figure 4.1b
Cabinet of Curiosities, 1690s, Domenico Remps.
Source: Museo dell'Opificio delle Pietre Dure, Florence.

In answer to the invitation to "make us something that will bring to life the knowledge of the enslaved" and my own wont to use plants as epistemic objects, I took the constraint of the CSSJ's very small backyard space—with neither the climate nor the room to plant crops of food or fiber—as a fitting injunction to trouble those earlier scientific visualizations of plant knowledge, as well as to honor the "tiny plots" or "huck patches" of the cabin and hut dooryards, where the enslaved planted and tended vegetable and root gardens.[7] Those patches supplemented a meager diet, even managing sometimes to yield a surplus sold at market, when slave-masters allowed, and were often bought up by the mistress for her own table (Heath and Bennett 2000; Heath 2001; Thomson 2008). In CSSJ's tiny garden are a few of the multipurpose flowering plants and medicinal herbs—including dandelions in profusion—that enslaved Africans in New England and elsewhere learned about and adapted, largely from Native Americans but also from the European colonists. I surmise that even those small patches of land had meanings that were not just utilitarian, as will be

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Figure 4.2a
Padua Botanical Garden, 1545.
Source: https://en.wikipedia.org/wiki/Orto_botanico_di_Padova#/media/File:Orto_dei_semplici_PD_01.jpg.

elaborated upon ahead. Therefore, the garden harbors as well some objects resonating African symbols and underlying cosmologies that enslaved persons reconfigured, in myriad open and clandestine ways, across the different natural and built environments of the Americas. Notable among the symbolic features of the garden are two which appear still, one way or another, in African-American yard art in the South: bottle trees and *dikenga dia Kongo*, the circular cosmogram of the once-powerful West Central African kingdom (Thompson 1984; Fu-Kiau [1980] 2001; Martinez-Ruiz 2013; Cooksey, Poyor, and Vanhee 2013; Sills and Als 2010).

However, as I worked through how to visualize this subjugated plant knowledge born of trauma and duress, it seemed as well that additional aspects about the reinvention and reassembly of knowledge around all three categories that I used to think with—plants of bondage, limbo plants, and liberation flora—might also be suggested in a piece of visual art.[8] This I decided to attempt as an assemblage, using only seeds, pods, and grains plus a few objets trouvés on background panels of African cloth and fibers associated with plantation slavery (see figures 4.3 and 4.4 for more details).

"To Set Going Something New": Assemblages, Visual Arts, and African Reinvention in the Americas

The leap of imagination from plantations and gardens of whatever type to an actual outside garden, symbolic or otherwise, is less a stretch of visualization technique than the seed assemblage, so it may be worthwhile to burrow into the thinking behind this choice.

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Figure 4.2b
Interior of the Great Palm House, Kew Gardens, 1852.
Source: Illustrated London News, August 7, 1852.

Assemblage is, of course, one of the most generative of STS tropes (Deleuze and Guattari 1987) to describe heterogeneous things or pieces of things—material, discursive, or both—in association with one another in a single context. However, the very notion of assemblage is also inherent in how the enslaved created and used their knowledge in the Americas. By taking a brief digression through Africana literature and visual arts, we can still use the term in its STS iteration but also give it additional meanings that may point toward other ways of thinking and talking about innovation, ways that put Africa and the African diaspora at the center of how we might construe differently the histories of plant sciences and technologies.

In art, an *assemblage* is "a collage incorporating material or objects other than paper and fabric," with objects predominating (Weiss 1979, 267). But for the artist Romare Bearden, a *collage* comprised "ritual or incantatory object[s]," extracting material from the world and

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Figure 4.3
The seed assemblage "Plants of Bondage/Liberation Flora."
Source: Author.

then transmuting it, "turning so many scraps of paper into a novel physical form" (DeLue 2012, 11, 13). In assemblages that often invoke Haitian and African women's power as well as "the pull of ancestral past and its subconscious memory," the artist Betye Saars uses artifacts, found objects, and personal histories to create a visual dialogue in small spaces, giving these things changed meanings (Carpenter 2003, 28). Saar's assemblages, she avers, are "a process of transposition and appropriation"—a notion that might also suggest another way to think about what the enslaved wrought and thought in their gardens. Seeds, then, with their power to imply both (1) the work of planting and cultivation and (2) generative, contained energies opening up to the new turned out to make optimal objects for an assemblage of plant knowledge of the enslaved.

There are also older, African genealogies for the technique of assemblage as visualization of knowledge and memory practice, just as there are in many indigenous knowledge systems. A *lukasa* (memory board) made by the Luba people (in Central Africa, present-day Democratic Republic of Congo), for example, is an assemblage made of wood, beads, metal, shell ... *and thought* (see figure 4.5). Indeed, it has been termed by art historians as "the motherboard of Luba thought," an organizer of data, a cosmogram, a history of sacred locales and much more, reinterpreted by trained court historians as they run their hands over the board in a tactile practice that reactivates memory in the presence of an audience (Roberts 2011,

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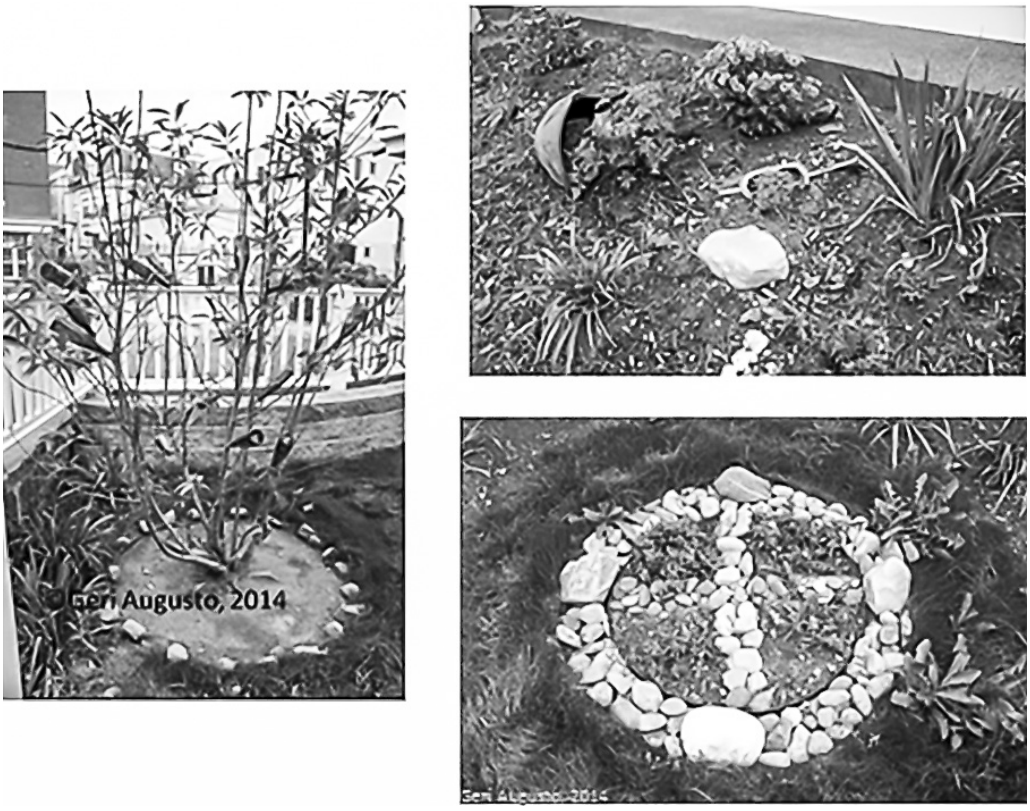

Figure 4.4
Aspects of the CSSJ slave garden.
Source: Author.

76). Mack (2003, 40–41) writes about lukasa as "thought retrieved from the intermediation of objects," objects that "articulate acts of remembering."

Notions of assembly and reassembly, acts of reinvention, translation, and innovation, abound in African diaspora literature and literary studies, as well as in discussions of African cosmological and sacred arts. This complex of ways to think about, make, and remake knowledge, prototypically the work of enslaved Africans and their descendants in the diaspora, I think of as *re/trans*. From this optic, we might pose a question: What if an "innovation journey" (Van de Ven et al. 1999) began in the dark, nauseating hold of a ship? Does not the reinvention of self as human, after that experience, and the transformation of less-than-optimal spaces into possibilities of survival, and even later thriving, count as innovation? The Caribbean scholar and poet Kamau Brathwaite ([1971] 1981) seems to think so, arguing that

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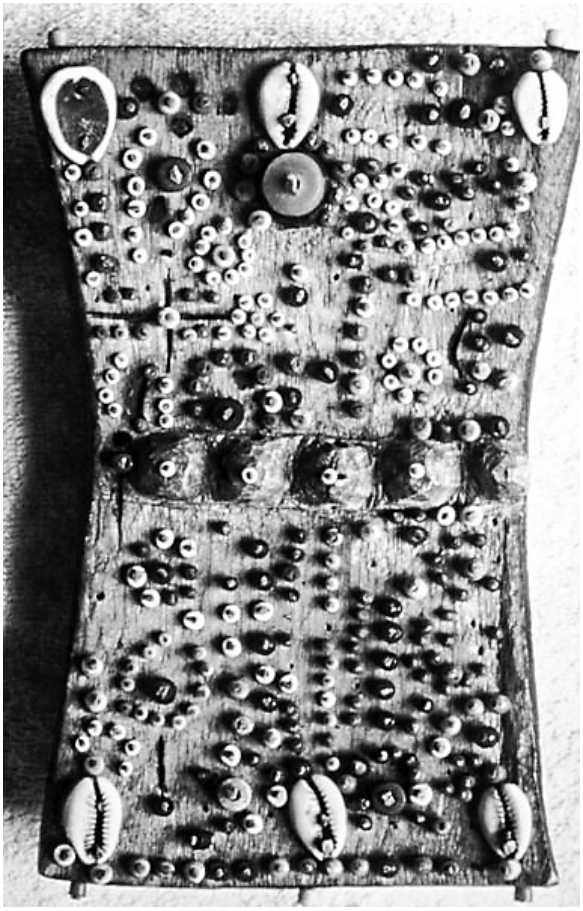

Figure 4.5
Lukasa.
Source: Eglash 1999, 166.

"the ex-African slaves and creole blacks in the Caribbean began from their first landings to adapt their African heritage to the new and changed conditions ... In the English islands at any rate, there was very little 'European' to adapt to" (6). It is important, Brathwaite continues, to study how enslaved Africans went about reconstructing lives from a "great tradition ... using the available tools and memories of [their] traditional heritage *to set going something new*, something Caribbean, but something nevertheless recognizably African" (6–7; italics mine). From this view, the infamous Middle Passage might be seen as "a pathway or channel between this tradition and what is being evolved, on new soil, in the Caribbean" (7). Monique Allewaert's (2013) provocative work of ecocriticism and "eco-poetics" on the ecological

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personhoods created in plantation slavery and maroon/quilombola cultures suggests that assemblage allows for the crossing of temporalities and spaces and the combining of fragments practiced by the enslaved or newly free, as well as their "modes of inhabiting the colonies and colonial histories that depart from the logic of colonialism and the modes of redress possible within it" (100).

In a similar vein, the prize-winning Guyanese novelist and theorist of the imagination Wilson Harris ([1970] 1995), in his classic text *History, Fable and Myth in the Caribbean and Guianas*, introduced a new usage of the quintessential Caribbean dance *limbo*, which myth has it first arose on the decks of the slave ships, interpreting it as "the renascence of a new corpus of sensibility that could translate and accommodate African and other legacies within a new architecture of cultures" (20). Elsewhere, Harris suggests metaphorically that limbo is a "novel re-assembly" arisen from "a state of cramp to articulate new growth ... a creative phenomenon of the first importance in the imagination of a people violated by economic fate" (20–21). This limbo assembly in the New World, Brathwaite argues, is African, but also incorporates "Amerindian features," and draws on a veritable "syndrome of variables" of architecture and visual arts, but also of technologies, born of "a long duress of the imagination" (Brathwaite [1971] 1981, 29). Jamaican cultural studies scholar Stanley-Niaah (Osinubi 2009, 179) links limbo to "new sensibilities of survivalism" and the reconfiguring of space under conditions of domination.

Hence it is from this Caribbean concept of limbo that I borrow the notion of *limbo plants* to describe those food and medicinal plants grown in the small slave gardens on plantations under colonial racial slavery. These were instances, anthropologist John Vlach (1993) argues, of the enslaved creating an alternative landscape and territory "beyond their master's immediate scrutiny, at the margins of the plantation"—a creative, if survivalist, response to their "assigned environments" in spaces "*open to and characterized by movement*" (13–14; italics mine). "Slave initiative" in their half-acre or less gardens, observers often remarked, was highly productive. Vlach goes on to recount: "The space around the slave cabins was highly charged with social symbolism. In their gardens, the part of the [slave] quarters for which they were most responsible, slaves were most effective in establishing a territorial claim within the plantation's confines" (168). Often though, as some former slaves testified, a particularly productive patch simply was snatched away by the master, and another space had to be claimed and remade (Blassingame [1977] 2002). Yet through their own enterprise and inventiveness, the enslaved somehow "kept body and soul together."

Irregular Rearrangement and Imagination: An "Aesthetics of Resistance and Identity"

Imagination, inventors and scientists from Albert Einstein to George Washington Carver have often asserted, counts as much as knowledge in innovation. The writer Alice Walker ([1972] 1983) reminds us that for a long line of African American women, from slavery to now, gardens have been a space for giving rein to imagination and an urge to create beauty

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otherwise suppressed under oppression. This is why, though it might at first seem counterintuitive that enslaved persons also grew plants for reasons of aesthetics and the will for an inner life beyond the reach of the lash or endless linear rows of commodity crops, I thought it important to include flowering medicinal plants in the CSSJ slave garden. They stand for that suppressed but indomitable urge to create for reasons of one's own. As art historian Leslie King-Hammond (2008) argues, in developing her notion of an "aesthetics of resistance and identity," such an aesthetics played out, among other ways, in gardens that focused on food and medicine but also included flowers:

> Surviving the American plantation system required enslaved Africans to locate spaces that were intimate and often obscure, where they could cultivate aesthetic sensibilities within and beyond the limitations of slavery. Enslaved Africans learned though ancestral memory, artistic innovation, and their own intellectual genius to identify safe and sacred "spaces of blackness" in order to resist domination and to protect their new sense of identity in the new world ... Some of these spaces were in their environments: their homes, gardens, communities and grave sites. (58)

Archival research on slave life and newer archeological and other studies of plantation material culture also note that the enslaved grew flowering plants for a multitude of purposes (Egypt, Masuoka, and Johnson [1945] 1968; Heath and Bennett 2000).[9] From the testimony of the enslaved in the WPA Alabama interviews, for example, it was clear that both vegetables and flowers were often planted in the slave patches. Tildy Collins, when contacted in 1937, was still living in her one-room cabin, with its "neat garden of vegetables and flowers combined, with morning glories trained carefully over the fence nearly all the way around" (WPA 1937, 83). The former slave Sam Aleckson testified that the crudely built cabins on the plantation in which he lived "had flower gardens in front of them" (Blassingame [1977] 2002, 255). Another ex-slave recalled poignantly from his childhood how each morning his mother, as she set out for an arduous day in the cotton fields, would let her eye linger a moment on her morning glory vines. It probably helped that some of the most useful plants for remedying illnesses, such as irises ("blue flags"), were also pleasing to the eye.

In his evocative introduction to a photographic essay on African American gardens across the US South, the swept yards in which they are often set, and the variety of containers they often feature, Lowry Pei traces these gardens back to those of the enslaved and their African ancestors. He goes on to describe their recurring "template" thusly: "Plants in containers as well as in the ground; used objects of all kinds, valued because they have been used and now appropriated for new purposes; circles; the color white; pipes, stones, shells; figures of human beings, animals, or birds; things that reflect or give off light, objects that refer somehow to wind, like chimes, pinwheels, and fans" (in Sills and Als 2010, xiv).

All of this, Pei continues, was built on irregular shapes, circles, and broken lines, forever open to rearrangement, "the opposite of formal European gardens," and with an underlying form which is "a set of values, a worldview," rather than a "perfectible product." That worldview, expressed on small plots of land, hearkens in part back to the mixed-crop polycultures

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typical of African farming before colonial occupation and to a different type of environmental imagination now transplanted and reconfigured, under circumstances not of the enslaved persons' own making or control. Yet they made of those plots things useful for survival, small constrained assemblages inscribed on unfree ground, but which sometimes helped lay the path to freedom.

Liberation Flora

Thus the enslaved Africans and their descendants drew on African concepts of how spaces for food crops and useful flowering plants should be set up, even under limbo conditions. However, they were able to give far fuller expression to those now-transplanted models when they escaped and created their own free communities in the very midst of the surrounding slave regimes in what were for them new, if somewhat familiar, environments. Some of the most admiring assessments of the flourishing, highly productive gardens and fields of African maroon communities (also known as *palenques* and *quilombos* in Spanish and Portuguese-speaking American societies) come from an unlikely source: the reports and drawings of colonial soldiers and military officers participating in the hard-fought assaults that finally succeeded in routing out and destroying them (Price and Price 1992; Reis and Gomes 1997; Corzo [1988] 2003; Augusto 2011).

These descriptions, time after time, depict richly polycropped, ingeniously defended, bountiful fields and gardens. These were spaces in which food and agricultural systems evinced that "hybridization and intermingling of planting methods and foods" (Carney and Rosomoff 2009, 112), based on the food and agricultural systems of both Amerindians and Africans, that would have first appeared as limbo plants on plantations. Maroons ate variedly and well by all available historical testaments. There is little research yet on whether or not new patterns of work and ownership emerged in the maroon communities, but some scholars have already suggested (Ellis and Ginsburgh 2010) that this might have been another opportunity for re/trans—older templates and forms, adapted to new conditions, the hard experience of breaking bondage, and the opportunity to inhabit freedom.

New Genealogies of Invention and Innovation

Reflecting on the botanical knowledge and technologies of enslaved Africans and Afro-descendants through the novel conceptual categories of *plants of bondage*, *limbo plants*, and *liberation flora*, mediated by tangible artworks and some of the intellectual resources of Africana studies, allows us to rethink how innovation is in some cases shaped by a most peculiar set of historical circumstances and how the human impulse to resist also summons invention. For enslaved Africans and their descendants, survival, resistance, and freedom shaped how plants were known, cultivated, and used. They themselves were made mobile involuntarily under duress, and their knowledge traditions and cultural templates, and at

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least a few critical seeds, came with them in a traumatic crossing of the waters. In the Americas, they developed new assemblages of knowledge and sowed them into differing landscapes, using knowledge practices we have captured here under the evocative rubric of *re/trans*. Given the centrality of racialized chattel slavery to the remaking of the modern world, the epistemic settings and practices in the production and reproduction of plant knowledge briefly interpreted in this essay should, we may reasonably conclude, constitute a critical part of more global genealogies and histories of innovation.

Visualizing in more engaging ways the ideas, cultures, and practices around plants wrought and reworked in the African diaspora by enslaved persons may open up conversation about innovation under extreme material difficulty and about making and remaking on the move while fighting for recognition of one's very humanity. That may be a good thing for the current generation of African and diasporic youth, who in many cases are fighting for recognition as well. Novel explorations of agrobotanical knowledge of the enslaved that use intellectual resources common to STS alongside those of Africana studies may also constitute another route to making STS more central to the study of Africa and the diaspora, and may help impel African knowledges from the margins to the center of the field. Whenever notions of creative mobility, assemblage, invention, and innovation are deployed in STS, shouldn't the Africans who were enslaved in the diaspora spring immediately to the mind's eye?

Notes

1. In this poem known in Brazil as the national hymn of the struggle for Black Consciousness, Assumpção writes, "I am the one who planted the fields of sugarcane and coffee, and watered them with sweat and blood ... And not even death will be strong enough to make me keep quiet" (my translation).

2. It must be stressed that I am not considering "Africa as a country," and I am cognizant of the diverse origins, societies, and cultures from which the oceangoing slave trades drew. Explorations of that diversity of plant knowledge more specifically by origin are not possible in this chapter, and such explorations are not its intent.

3. I first coined the expression *epistemic walk* in two talks: a March 2004 conference presentation on the useful plants garden at Kirstenbosch at the first South African Academic Colloquium on Indigenous Knowledge Systems in Bloemfontein, South Africa, at the University of the Free State; and an Africana Studies Department senior capstone seminar at Brown University in February 2005, entitled "Xhosa Hut and Palm House: Africana Knowledges, Space and Methodology."

4. Switching the directionality of African agronomic innovations back the other way for a moment, it is worth recalling the tremendous feat of adaptation and reinvention in technologies carried out with resounding success by African women farmers who took up the cultivation of the Amerindian plant maize, as McCann (2005) skillfully recounts.

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5. As the former slave John Anderson declared when interviewed in 1861 from his new home in Canada, when explaining what his patch-grown tobacco went toward: "And in this way some acquired sufficient means to purchase their freedom" (Blassingame [1977] 2002, 353).

6. Delbourgo (2010, 113) argue:

> Strikingly, only in the last few years have scholars begun to examine the agency of the slave trade in circulating natural knowledge, suggesting the possibility of overcoming the long-standing notion that slavery and science had nothing to do with each other, and that the "social death" of enslavement denuded African migrants of all epistemic capacity. ... Treating Africans as subjects and actors in early modern histories of natural knowledge is a recent development. Scholars have now begun to raise pressing questions about Africans as active carriers and producers of botanical and medical knowledges, as collectors, expert cultivators, keepers of provision grounds, and skilled poisoners. The link between institutional science and the slave trade, meanwhile, has always been hidden in plain view in the British case, as demonstrated by the overlooked career of Sloane—the future Royal Society president and British Museum founder who gathered specimens in Jamaica.

7. I am indebted to the offer from CSSJ Director Professor Anthony Bogues to use my imagination in this way, which made it possible for me to undertake gladly what I consider the fulfillment of an obligation (*obrigacao*, as they say in the African-derived Brazilian religion of candomble) to my enslaved ancestors.

8. This work originally carried only two of the concepts in its title; the third, the notion of limbo plants, emerged later in the essay drafted for the MIT workshop that led to the present volume.

9. This notion of plants as inherently multipurpose, escaping labels such as *medicinal plants*, has been retained in many contemporary indigenous medico-therapeutic knowledge systems in Africa; see, for example, Augusto 2004.

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5
Smartness from Below: Variations on Technology and Creativity in Contemporary Kinshasa

Katrien Pype

What do innovation and creativity mean in Kinshasa, capital city of the Democratic Republic of Congo? What can a social exploration of innovators and creative Kinois (inhabitants of Kinshasa) tell us about Kinshasa's society? What can an anthropological perspective add to our understanding of the dialectics among technology, culture, and society? In this chapter, I attempt to formulate an initial response to these questions. However, because Kinshasa is a complex city housing millions of people with their own desires, aspirations, and stances toward the future and the role of materials therein, my answers can only be partial, plural, and provisional.

This ethnographic complexity should not be taken as an obstacle, but should rather be approached as a challenge to the researcher to look for coherence, interfaces, and connections. To do this, I will explore the connections between different spheres of Kinois society (politics, education, healing cults, urban music, etc.), taking ideas and practices surrounding technological *innovation* and *creativity* as the main connectors between these spheres. As such, this chapter is a thought experiment as well as a methodological exercise. The goal is to show alternative modes of thinking about and handling technological objects. The material presented here, informed by ethnographic research in Kinshasa from 2003 on, should be understood as an attempt to sketch the sociohistorical contours of advances in technology and various forms of engagement with tools, scientific knowledge, and technological expertise in an African city.

My main entry into the topic is oriented by linguistic facts; language is an important point of entry for understanding societal phenomena. In line with an anthropological approach that looks for *emic* perspectives of cultural phenomena—that is, the perspectives of those who participate in the society—I take Lingala (Kinshasa's lingua franca) and kiKinois (Kinshasa's street language) to provide legitimate entry into the study of signification and meaning production in technological worlds. The standard Lingala for *to innovate*, *kosikola*, has multiple meanings. It can also be translated as *to choose, to select*, and in a Pentecostal context the same verb denotes *to deliver (from evil spirits)*. Linguistic evidence thus suggests that there is more to the notion of *innovation* than is commonly assumed in the scientific-technological

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discourse that dominates academic understandings of technological worlds. Ontologically, these alternative meanings suggest that everything exists. The innovating agent knows which choices to make and pulls things from an invisible realm into the material world. Innovation then depends on knowledge—a spiritual knowledge or, in a more practical sense, a know-how deriving from invisible ontological worlds that tells the actor or agent which option or strategy to choose in order to attain a given goal. Furthermore, the verb *to know* can be translated as *koyeba* or as *kozala na mayele*—that is, *to be with knowledge*. *Mayele*, or *knowledge*, is a highly polysemic word as well. A Lingala-French dictionary (Kawata 2003; my translation) defines *mayele* in the following ways:

1. Knowledge, intelligence, malice, prudence, wisdom
2. Artifice, astuteness, deception, bad intention, intrigue, ruse, trick
3. Manner, way, tactic, tact
4. Spirit, mentality

Mayele can thus mean at once the wisdom accumulated through experience and the intelligence obtained through schooling. The second sense has a social meaning; it refers to aspects of deception, trickery, and fakery, all practices that involve victims. Here, the moral economy of *mayele* comes to the fore. Significantly, outside of the language of dictionaries but in kiKinois, a whole series of synonyms (*mystique, na boule, smart*) have become fashionable to highlight creative, inventive ways of living life in Kinshasa. As I elaborate throughout this chapter, each of these synonyms has gained currency within particular sociotechnological worlds and carries its own connotations while embedded in different scales of reference.

Perhaps provocatively, I propose to take the semantic layers of the verb *kosikola*, the noun *mayele*, and the latter's synonyms as models for the ethnographic exploration to follow. In a dictionary, the various denotations ascribed to a single signifier are related to one another in variable ways. In some cases, the associations are clear to many; in others, only a few might see the connections; and in some instances, even the native speaker is puzzled as to how a signifier can combine particular denotations. The arrangement of the ethnographic material in this chapter is composed in a way similar to a dictionary entry with multiple meanings. The various spheres of Kinois society that are brought together in this chapter should be read as different worlds of meaning that coexist in the extremely complex city of Kinshasa, where expectations about and practices of technological innovation and creativity carry particular meanings and denotations, but also connotations. Some of these worlds are more intimately linked than others and will express overlapping meanings. Above all, the worlds brought together in this chapter are connected by the linguistic forms described previously. This connects with the epistemological challenge of this article. I contend that we must remain open to the polysemy of technology, innovation, and creativity and take a culturally sensitive approach to the closeness of meanings and practices in technology worlds. Attention to closeness, as resemblance of form, adjacency in value, or even collision of tools, is necessary if we want to understand how people live with technology, in Africa and elsewhere.

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My method, which can be summarized as *exploring polysemy*, will allow me to relate the various vernaculars of *mayele* (*mystique, na boule, smart*) to cultures of technology and urban sociality. The analysis will thus bring together urban anthropology and anthropology of technology from an African perspective. In recent years, the social study of urban Africa has gained a new breath. Authors like De Boeck (2011, 2015), Simone (2004), and Pieterse (2008) have drawn attention to the ways in which social infrastructures (kinship, religious associations, etc.) provide important safety nets for African urbanites to survive. These analyses describe the city's infrastructure as a material space both frustrating city dwellers *and* providing new opportunities. By focusing explicitly on the lacking or malfunctioning hardware of the city that blocks or hampers residents in their daily lives and in their search for a better life (see Larkin 2008), the question of innovation becomes crucial. As Nowotny (2006) reminds us, technological innovations speak to issues of intentions, effects, and transformations. Innovations come about with particular goals, desires, frustrations, and problems in mind. I propose to explore these social contours of technological creativity through the rubric of *smartness*, a concept intimately tied to innovation. What does it mean to be *smart* in Kinshasa? Who is smart? Who is not? How does mastery over entering technologies relate to local repertoires of authority, power, and prestige?

I thus attempt to unsettle the ethnocentric assumptions of *being smart in the city*. A telling illustration of these postulations is Tim Smedley's opening of an article in the Guardian on the "adaptation of smart cities for the Global South" (Smedley 2013). He quotes Pieter van Heyningen, programmes manager from the Stellenbosch Innovation District (SID) in South Africa, who argues: "Smart cities are very much a developed world concept." Van Heyningen identifies the establishment of so-called smart governments, smart healthcare, smart buildings, smart mobility, smart infrastructure, and smart technology in African cities as huge market opportunities, until now scarcely seized upon by entrepreneurs. There are two pitfalls in this statement: First, it suggests that smart cities are out of place in Africa, yet urban authorities in Kigali, Nairobi, Harare, and Cairo are all negotiating with private entrepreneurs to "smarten" public transport, healthcare, and education. Furthermore, the qualifier *smart* (in English) is gaining ever-more currency in African cities, including in Franco- and Lingalaphone Kinshasa, and is exploited by entrepreneurs, politicians, and cultural actors who appropriate the label and twist it to suit their own desires and goals. Second, the statement also suggests that if African cities become "smart," it will be because of the usage of Western technologies and urban programs brought in from the "developed world." Alternative ways of being or becoming smart are not imagined here.

I propose to approach "smartness" in Kinshasa, the capital city of the Democratic Republic of Congo, from below—that is, through the ways in which Kinois deal with innovation, technology, and creativity and talk about ways of creating knowledge, tools, and practices necessary in urban life. As such, I set out to "examine the encounters of incoming technologies with local creativities, cultures, societies, and territorialities" (Mavhunga, Jeroen, and Pype 2016, 47). As I, together with Jeroen Cuvelier and Chakanetsa Mavhunga, argue, we

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need to "break away from taken-for-granted assumptions about technology transfer, according to which most technology travels from the Global North to the Global South, where it is adopted for the common good" (47).

The material derives from fieldwork in Kinshasa. Since 2003, I have conducted empirical research in the city, mainly on its popular cultures and media worlds. Since 2014 in particular, I have begun to think about technology infrastructures in the city, thus paying attention to the material sides of information and communication technologies. Observations, interviews, and media analysis form the basic methods of my research.

Innovations for the City

Kinshasa, home to more than ten million inhabitants, is one of Africa's megalopolises. Its inception is connected to the railroad, established by the Belgian colonizers in 1898. The expansion of the area gradually incorporated the land of ethnic groups such as the Teke and Humbu people. During colonial times, the colonizers set up an impressive electricity grid and sanitation for the urban residents. During postcolonial times, these infrastructures have received scant renovation or even basic maintenance. In recent years, especially since 2006, current president Joseph Kabila has made the renewal and expansion of housing, health infrastructure, education, energy, and transport into the key components of his political campaign, summarized in the slogan *La révolution de la modernité*. For many Kinois, nice housing with running water and constant electricity remains but a promise (De Boeck 2011). The reality is that most people live with irregular power cuts, never knowing when electricity will return or if water will suddenly stop running. The state agencies for water and electricity provision (SNEL and Regideso) have become objects of mockery, attacks, and scorn in Kinshasa. Their agents are met with verbal abuse when they present their bills, and corruption appears to be the only way of lowering the amount one will be asked to pay.

Intimately tied to the (re)construction of infrastructures is the reactivation of local industries. Here, the French term *innovation* is an important concept on the political agenda. Since 2013, the minister of small and medium enterprises and of industry organizes an annual *Salon d'Innovation*. This event, national in scope, relates to the imagination of the Congolese nation's future, as indicated by the 2014 theme, "Young African, you have to believe in Africa, in yourself and in your country," which relates to self-worth, African pride, and trust in the national government. Explicitly set within the president's political campaign of *La révolution de la modernité*, the *Salon* is embedded within national politics and the elite's imagination of how Congo's future should look.

The *Salon d'Innovation* also ties into a wider "global quest for innovation" (Nowotny 2006, 5). From the beginning of the twenty-first century, as Nowotny shows, the quest for innovation has achieved prominence and urgency all around the globe. In particular, a discursive focus on innovation is emerging, which, according to Nowotny, "fills a conceptual void in our collective imagining of the future" (5). Although she is not speaking directly about the

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African continent, Nowotny's ideas about the "culture of innovation" are also relevant for Kinshasa's national space. Thinking about the future has become less mechanistic and naïve, Nowotny claims, and "questions have shifted toward knowledge of the actors imagining different kinds of futures" (5). She also diagnoses a changing relationship between the state and the market as a cause of the conceptual void. The *Salon d'Innovation* is embedded in renewed attempts by the Congolese government to stimulate economic growth and the local industry.

However, we can perceive disconnect in the various temporalities of innovation as they are evoked by state officials, by Kinois residents, and even by Kinois innovators. Despite the state's emphasis on the future, Kinois are more interested in the possibility of immediate innovation solutions. This idea is illustrated by newspaper and street discourses on the inventions presented at the *salon*, which showcased a whole range of local and international inventions. Tellingly, a journalist's report in the local newspaper *Eco243* selected only the following two inventions:

> In the minister's tour of all the stands, we saw young innovators [*innovateurs*] presenting their creations, for example Matela Mandela Joseph has presented "an automatic electro-mechanical switch." This invention has the advantage of producing electricity, with 8 regular batteries that can operate a mobile telephone. And if we add a 12 Volt battery with approximately 120 or 90 amperes, then Mandela's device can power a fridge or a television set. Mandela is also the inventor [*inventeur*] of "an automatic phase switch and temperature sensor" in a short circuit to prevent damage. (Ntangu Lihau 2014; author's translation)[1]

Significantly, the news report ends with a short phrase merely stating that during the fair, mobile banking was explained to visitors. Other inventions presented at the fair are not even mentioned. With his urban readership in mind, the journalist's selection suggests that inventions concerning electricity are the most significant creations presented at the *salon*. As such, we get an indication of what Ntangu Lihau thinks innovation should be for: It needs to make life easier *today*. The major problems of the day are indeed power cuts—and the loss of electric goods due to the instability of electrical power.

Intelligent traffic robots were also presented at the *salon*. These robots were installed in Kinshasa in 2014 and operate on several central roads in the city center. Created by a female engineer at the ISTA (*Institut Supérieur des Techniques Appliquées*; Higher Institute of Applied Technologies) campus and a group of fellow engineers, these robots have made the headlines of major world newspapers, inspiring debates about gender, aesthetics, and technological creation. Most Kinois applaud the installation of these "intelligent traffic robots," which take over the work of policemen, imitating the gestures of traffic police to control the flow of cars, trucks, and motorbikes. Powered by solar panels (without batteries to store energy), these robots mainly function during daytime.

The robots relate to an experience shared by African city dwellers. As most Kinois argue, the major gain of the *robots de roulage intelligents* is that these nonhuman traffic policemen

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do not chase drivers with false accusations of, for example, having ignored their signs or having too many passengers in the car or not having used a turn signal. It is exactly these kinds of predicaments of urban life that push people to invent and to be creative with technology. Many of my interlocutors during the course of my research claimed that city authorities should invest in these robots and put them on all traffic hubs. Replacing corrupt policemen with smart traffic robots makes life in the city easier. These are the inventions for the everyday (Mavhunga 2014) that the population eagerly embraces.

Mystical Knowledge

Beyond the realm of creating something new, repairing is also a practice of creativity. The following story from fieldwork brings forth the meanings and materialities of expertise and technological appropriation in a nonpolitical locale: the city's marketplace radio studios.

It was July 19, 2014, 14:25 pm. The evangelical radio station had been booming through the loudspeakers on Kinshasa's Central Market. Suddenly, the speakers went dead. Instead of the familiar gospel rumba broadcast, the noises of vendors attracting their clients, manioc mills, and transistor radios took over. Pastor Jean and Pastor Enice, who had been preparing to collect money from the vendors supporting them, immediately knew that the problem with the electricity transmission was to be found in the tiny studio. The manioc mills also used electricity provided by SNEL (the national electricity company), but their noises let the pastors know that the mills had not stopped working.

Therefore, the two pastors, who spent six days a week in the market evangelizing via the market radio, started investigating each cable that connected the PA mixer amplifier (SSA 160DP) with the mobile phone (Samsung E150) on which the gospel songs were stored. With great caution, they lifted the ventilator, which was laid upside down on the amplifier to prevent it from overheating. The multisocket extension into which the other devices were plugged was investigated as well. The extension also fed the mobile phones of some people working in the market, who used the radio's electricity to charge their batteries. The pastors quickly glanced at the cable that fed the socket extension and the loudspeakers. It is impossible to say what order the verification happened in, as the movements of fingers, of arms following cables, and plugs being pulled out and then put back in happened rather quickly and seemingly outside of any logical order. It all happened in silence, until Pastor Enice discovered that one of the mobile phones had slid from the windowsill. Patting his fingers on the socket while bending underneath the table to pick up the mobile phone, Pastor Enice asked out loud: "What do we have here?" After a few minutes, I noticed how Pastor Enice opened one of the cables again, on the outer end. He manipulated the electricity cables, plugged them as they were (without the body of the plugger, so just the two cables) into the socket, and the gospel music returned. Pastor Enice watched me watching him, smiled, and said, "Biloko ya mindele eza na bacaprices" ("The goods of the white men are capricious").He continued: "All tools have their own whims. It is by blacksmithing that one becomes a

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blacksmith." He assumed that the vibrating function was activated when a call came in. This must have set some small movements in motion, with serious consequences for all the other apparatuses and cables.

The tools are "capricious," Pastor Enice explained. The label *capriciousness* humanizes the inanimate. On the one hand, one could say that asociality is attributed to technology. *Capriciousness* refers to an animated object (person, animal, energy, etc.) that is difficult to control and master. Just like a capricious girl leaves the house whenever she wants or does not carry out the chores her guardians order her to do, so too are cables very sensitive and have their own ways of working—or stopping work. Yet capricious behavior, just like other kinds of asocial attitudes and actions, is said to have spiritual origins (Pype 2015). Indeed, if humans are capricious, it is because the spirit world at large is whimsical. As most Kinois agree, spirits can become jealous or angry merely because of words, intentions, or laughs from human beings. Of course, Pastor Enice did not suggest that the cables had been moved by spiritual agents. Significant, however, is that the spiritual world bears symbolic relevance for the minor accident in the radio studio. This recourse to idioms about the spiritual should be taken seriously, even when studying a seemingly secular, rational, and highly technical event.

There are additional correlations between repairing faulty technology as Pastor Enice managed to do and the spiritual world. *He is mystical* (*aza mystique*) is a phrase Kinois express commonly—and often jokingly, but usually also in admiration—when a person has succeeded in getting a rusty television set, a broken radio, or a "dead" mobile phone to work again. The concept of *mystical human beings* pushes us into the domain of *kindoki*, secret knowledge, knowledge about the invisible powers that govern the material and the societal. In Kinois parlance, engines and electricity-powered technologies are usually defined as *kindoki ya mindele*, mystical knowledge of the white men. Examples include motorcars, airplanes, kitchen robots, mobile phones, and the computer. *African occult knowledge* (*kindoki ya biso*, or our *kindoki*), by contrast, refers to the various magical practices that witches and so-called traditional healers set in motion. I have studied the embedding of communication technologies such as the television, radio, and mobile phone in bewitchment and healing practices elsewhere (Pype 2012, 2013). In these practices, emotions, expectations, and intentions charge technology use with spiritual qualities that in turn impact individual users and receivers.

Although in emic understandings there might be clear distinctions between the two kinds of *kindoki*, in practice there is much overlap. Television and radio are embedded in divination and healing practices.[2] Here we arrive at a first dimension in the cohabitation of new technologies and indigenous forms of knowledge production. Significantly, the possibility of confusion between human beings mastering technology and spiritual powers manifesting themselves through that same technology is something that colonizers enthusiastically exploited in order to discipline their subjects. Ramirez and Rolot (1985) describe how missionaries in Congo did not make an effort to demystify the workings of cinema. Behrend

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(2003, 132), in the east African context, describes a similar contribution by colonizers in "convert[ing] technology into magic." She writes: "Europeans—missionaries, colonial administrators, explorers, and travelers—also used the instruments actually intended for scientific research and documentation, especially the camera, to create 'wonders,' in order to astonish and terrify Africans." Drawing on archival sources, Behrend shows how in the nineteenth century missionaries and colonizers presented themselves as medicine men, producing charms for Maasai warriors to become stronger and more successful in battle, or else used photography as proof that they possessed supernatural powers. The missionaries' reports suggest that Europeans possessed (technical) knowledge that enabled them to magically dazzle others.

Blacksmiths and Engineer Students

The exact words Pastor Enice used when trying to find the origin of the market radio's breakdown were *technique nionso*. The French *technique* refers to an amalgam of practices and know-how. The Greek root of *technique*, τέχνη, *techne*, denotes art, skill, and cunning of hand. *Technique* thus constitutes a craft, a collection of wisdom and knowledge for how to use tools. This emphasis on craft draws us to the associations between technology/technique and *kindoki*. As mentioned, in its basic sense, *kindoki* refers to a particular kind of knowledge, spiritual knowledge. A *ndoki* possesses knowledge about the invisible worlds and knows how to effect change in the material world. A ndoki is closely connected to the *nganga*. In Lingala and kiKongo, the concept of nganga incorporates the priest, the doctor, and the professor. A nganga is an expert, has power, and possesses religious, medical, and/or scientific knowledge. According to this logic, experts in "the kindoki of the white men" are engineers, inventors, and those who master biology, physics, and chemistry. However, Pastor Enice himself, a man with deep knowledge and know-how about the sacred, had never studied electricity, and it was in what appeared to me to be a very improvisational way of readjusting the electricity wires that he managed to get the radio equipment functioning again. His expertise as a pastor did not help him at all.

However, adding that "while blacksmithing, one becomes a blacksmith," Pastor Enice extended the idiom of spiritual knowledge. Surely, he did not identify himself as a blacksmith, nor did he claim that the repair work was anything similar to the work of a blacksmith. Yet Pastor Enice's choice of the blacksmith was not incidental. Rather, his choice of words reveals an *analogy*, a closeness with the techne expert and the blacksmith regarding the transmission of knowledge (or even better, know-how) and the social positioning of both.

First, the idiom "while blacksmithing, one becomes a blacksmith" draws our attention to the role of apprenticeship in the transmission of techne. Apprenticeship is a mode of transferring knowledge and expertise through observation, imitation, and practice. Pastor Enice had not received formal schooling in which technology is explained to students. Rather, as a

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man coming from Mbuji-Mayi, where he had been a journalism student, it was only when he started to evangelize through the medium of radio that he learned how to repair broadcasting equipment. The head of the evangelizing radio stations organized a basic training session on how to handle the material. After this session, all radio hosts were to run their radio studios in teams of two. They were asked to repair the equipment based on their own know-how and experience. Due to their intimate knowledge of different cables, faulty sound systems, and mobile phones, the *animateurs* managed to repair the equipment time and again. Just as an nganga's knowledge is embodied, tacit, and difficult to articulate, Pastor Enice could not really explain how he had managed to find the source of the problem. Rather, he *speculated* that an incoming call, triggering the vibration function on the mobile phone, might have set some changes in motion in the assemblage. He was not sure, though—and in the end, it was not that important whether he was right or not. The reference to the spiritual world continues here. Just as the nganga's explanations for afflictions might be ironic, ambiguous, and ambivalent (see Peek 1991), so Pastor Enice's explanation *could* have been true, just as it *might* have been wrong. In both contexts, it is not so much the "real" origin of the failure that is relevant; rather, a *possible* cause should be voiced in order to allow a rationale for correction and repair to be set in motion. In the market's radio studio, it was the functioning of the radio that mattered more than finding *exactly what* had caused the rupture. Again, it is important to emphasize that Pastor Eunice did not claim to be a diviner—and the use of the blacksmithing training idiom should not be seen as an anachronistic interpretation of working with technology. Rather, the behavior that I observed bears many similarities to how one explains divination practices. Divination is a symbolic model for survival and life, with material infrastructure (De Boeck 2015) and (faulty) technology included.

Also, my approach to technological repair as an nganga's way of reading signs and explaining the world is by no means an attempt to confirm or reinstall Levi-Strauss's infamous distinction between the *bricoleur* and the engineer. Rather, diviners and scientists alike, just like laymen, use the trial and error method in order to advance in their own domains. Similarly, Trovalla and Trovalla (2015, 332) have recently observed the ways in which residents of the Nigerian city of Jos live with faulty technological infrastructures. They write: "The infrastructural landscape is one that continually mutates and needs to be re-read and where getting access to services hinges on one's prognostication skills." The city's infrastructure "is turned into a soothsaying device and its residents into diviners" (333).

Divination systems are open-ended dynamic systems of knowledge that allow for different experiences and interpretations to enter (see Peek 1991). To add to the openness and ambiguity of divination systems, the diviner often cannot bring forth a final diagnosis and action plan without the client's presence (Peek 1991, 2). The divination is a dialogue: It is not the diviner himself who knows (or receives) all the right information; rather, the knowledge is co-constructed. The "expert" is not a know-it-all but rather depends on others to formulate routes for repair and solutions. Divination is collective construction of knowledge, obtained

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through the handling of materials and communication with the otherworldly in the search for causes of failures. The analogy between divination and handling technology *decenters* the technology user in our analysis of technology transfer. This decentering of the technology user allows us to bring other "agents" into the analysis of technology use (repair, instruction, etc.) by acknowledging the (symbolic) intervention of spirits, as well as the equipment itself (very much like Actor-Network theory). It also allows for indeterminacy, ambiguity, and the enigmatic in people's handling of technology, a topic to which we will return to later.

It is worth pausing to consider the social positioning of blacksmiths—that other category of experts that Pastor Enice evoked when looking for a solution in the market radio studio. Blacksmiths are regarded ambiguously in Congolese society (as well as in Nigeria [Njoku 1991], Zimbabwe [Mavhunga 2014], and Tanzania [Wright 2002]) because fire (*moto*) is at once a purifying tool in witchcraft eradication and a symbol of social reproduction (de Heusch 1956). Blacksmiths and chiefs are closely related within ethnic groups, which gives them a measure of political power (de Maret 1985; MacGaffey 1986). Furthermore, because blacksmiths provide tools for the nganga they also perform a fundamental role in healing cults. This all leads to a perception of blacksmiths as people with mystical powers. As a consequence, just like nganga, blacksmiths are feared.[3] Here, we arrive at another dimension of technology use: The display of expertise over materials can induce fear and awe, separate those "with knowledge" from those "without knowledge," and introduce new dynamics of power, distinction, and authority.

In Kinois society, knowing too much about techne in general also induces fear. The excess of techne is more fully embodied in the lifeworlds of engineer students. The social positioning of these students perpetuates this dimension of what it means to master technology, in contemporary Kinshasa. As students, they are engaging in formal training to become experts in techne. In their liminal, betwixt and between position as students, their bodies become burdened with too much knowledge, which they have not yet learned to discipline. ISTA is one of the very few institutions at which engineers are formally schooled in Kinshasa. In contrast to students enrolled in other colleges and universities, ISTA students have a reputation for being violent and capricious. In particular, they are feared for their violent interventions during funerals and their brutal punishing of individual and collective enemies. For example, ISTA students are known to burn houses down of fellow students studying on other campuses who have defied ISTA's reputation. Many people can also tell the story of how ISTA students set fire to the rehearsal compound of one of Kinshasa's most famous musicians after he insulted ISTA; students also are known to have burned down a football player's parents' house because he scored a goal against his team while playing with the national team.[4] The brutality and force used by ISTA students is a major source of concern for police, who themselves do not interfere when, for instance, ISTA students take over traffic regulations; journalists also self-censor their reports and do not cover ISTA students' violence out of fear of retaliation.

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The impunity ISTA students enjoy derives not from the spiritual sources of their knowledge but from an arrogance that can be associated with the capriciousness of technology. ISTA students are aware that modern society is literally built on their know-how, their management of infrastructure, housing, and electricity. Although not all engineers actually find a job, they possess a strong sense of self-worth and are aware of their profession's necessity for Kinshasa's future. This self-worth pushes them to distinguish themselves socially from others in their imagination, and thus it encourages them to situate themselves above the law and violate customary taboos (e.g., their interventions at funerals, where ISTA students chant songs insulting women and shout obscenities while driving stolen motor trucks). We can ask, in an ironic way, whether the "spirit of the capricious techne" is possessing the engineer students.

Experts of the City

Artists and cultural entrepreneurs constitute another type of experts in contemporary Kinshasa, experts who further unsettle the idea that innovation and expertise stem from laboratories and scientific engineering studies (see chapter 2, this volume). Continuing with material from the production of popular culture in contemporary Kinshasa, I want to draw attention to the ways in which elderly Kinois are presented to the city as nganga. In the symbolic space of music TV shows, where elderly Kinois dance to 1950s and 1960s rumba music, the latter are designated as "experts" (nganga) of the earliest years of Kinois society (Pype 2016a). Their expertise relies on their intimate, embodied knowledge of that era's dance styles, of lyrics from the earliest Congolese modern songs, and on their close connections to the founding fathers of Congolese rumba music. *Vedetis*, *fanatiques*, *ngembos*, and boys who opened the dance floors were the first urban youth in Léopoldville, as Kinshasa was called during the colonial era. Presenting these people, who have become old in age, as nganga nowadays means acknowledging their value and knowledge of the origins of Kinois society. Yet the connections between expertise and popular culture go beyond knowledge of the city's music history. Charismatic musicians who invent new music styles are called *docteurs*. Probably the best known docteur is Docteur Nico, a guitarist and composer belonging to the first generation of Congolese dance music creators (1950–1960). Although trained as a technical teacher, he devoted his life to the guitar and—even decades after his death—continues to enchant masses of rumba lovers. It is precisely his mesmerizing manipulation of the guitar that has led people to attribute the name *docteur* to him.[5]

Docteur Nico's—or any other outstanding artist's—nganga qualities express first and foremost the capability of artists to attract people's attention. Fans of Docteur Nico's finger play with guitar chords are physically pushed to start moving their bodies; similarly, television spectators cannot wait to watch the parts of serials starring Muyombe Gauche, for example. This power, a force often called *charisma*, is used differently than in a Weberian sense. In the Kinois context, *charisme* combines skills, knowledge, and occult powers. Rumors abound

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about how successful artists have sacrificed relatives, band members, and sometimes even fans in exchange for popularity and material gain. Possessing charisme is the result of ties with invisible powers (White 2008). The same goes for ideas about innovation. *Mystical* is a term used to describe those artists and creators who have invented something. Here, I want to return to the concept of the mystique that I discussed earlier. *Oza mystique* is often said in admiration and jokingly, as the normal connotation of *mysticality*, and refers to the *unheimliche*, that which is "difficult to place, interpret and attribute meaning to" (De Boeck 2004, 58). The elusiveness of those who manage to survive in the city, stand out, and even become rich is tied to the city's continuous transformations. Its inhabitants are constantly trying to adapt to a morphing urban environment. In Christian speak, Kinois survive in *miraculous* ways (Persyn and Ladrière 2004); this does not so much suggest the genius, creativity, and resourcefulness of Kinois as the impossibility of interpreting how, despite a lack of money and work, people still manage to survive. Again, the terminology of a *miracle* is borrowed from the spiritual world. Yet because survival is seen as a positive result, a divine source is identified: Only God performs miracles. Bad spirits produce *demonic*, *worldly*, *païen* ways of surviving. From a Christian perspective, then, *la débrouille* (also known as Article 15), as a way of surviving in illicit, informal, and sometimes illegal and almost criminal ways, oscillates between the miraculous interventions of the divine and the demonic attempts of the devil to steal the souls of city dwellers.

Other types of experts *of* the city in Kinshasa are the *Yankees*, who in contrast to the *Yuma* refer to Kinshasa's streetwise people; they know how to use violence, fraud, fakery, and intimidation in order to survive. As Kinois see it, a Yankee has *boule* (*aza na boule*; he is streetwise). According to Zacharie Bababaswe, one of Kinshasa's main innovators in street language, *boule* means "the supreme phase of intelligence. A *boule* stands above all reflection. While reflections are limited, *boule* knows no intellectual limitation."[6] *Boule* refers to the drug hemp (*chanvre*), which is made into the shape of a nut before being consumed. Thus, *boule* leads us into the terrain of urban street culture, illegality, and trance. Bababaswe thus also hints at nonhuman spheres of intelligence and smartness. This unlawful, creative, and ingenious type of smartness is constitutive of urban life—not only in Kinshasa, but elsewhere too. Newell (2012, 12) describes how in Abidjan a *gaou* is "a fool, someone incapable of discerning his surroundings, and therefore someone easily duped." A *yere*, by contrast, cannot be scammed, but will steal from others. Interestingly, Newell draws an explicit connection between the yere and the *féticheur* (a particular type of nganga; a witch doctor). To be a yere means to be able to see things clearly, just like a "*féticheur*'s ability to see into the mystical goings-on of the otherworld, where witches, spirits and *jinnis* are at work." *Yere* then "refers to more than ordinary clarity of sight ... to see beyond the surfaces of things to the inverse, behind-the-mask realm where potency exists" (12).

Probably the best example of the intimate connection between the city and the creation of specifically urban knowledge manifests in the nickname that inhabitants of Dar es Salaam have created for their city: *Bongo*.[7] Derived from the Swahili *ubongo*, meaning brains,

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Bongo, when applied to Dar es Salam, suggests the "brains" one needs to survive in that city. Bongo Flava, then, the genre indicating the hip hop culture of Dar es Salam suggests the close connections between gangsta style and urban skills. As Stroeken (2005) indicates, Tanzanian hip hop became a space of knowledge production. *Bongo* "originally referred to the cunning needed to live in a city like Dar es Salaam and to cope with the cynicism of wages so low they presuppose additional income from illicit schemes, informal economy ... or fanning at the periphery of town" (1). Interestingly, Stroeken (2) makes a distinction between Bongo and the Kinois laws of *la débrouille*. He argues that to *boil the brains*, in a Tanzanian context, includes knowing where the limits are; such limits are not inherent to Article 15. One could approach Bababaswe's interpretation of *boule* as intelligence beyond limits in a similar vein.

These stories about popular culture and music in Kinshasa, Abidjan, and Dar es Salam in connection with youth and elders show that ideas about expertise and knowledge can also be found in music and dance. The realms of popular culture, expertise, and science should not be kept apart. The appearance of the nganga and mystical qualities, attributed to those who produce captivating sounds and those who can survive in the city, connect these spheres. The polysemy of the word *nganga* allows for an understanding of how music, street culture, and healing cults are linguistically interconnected. These constitute coexisting spheres of world-making, agency, and creativity, each requiring particular forms of expertise and thriving on distinct (though sometimes overlapping) tools and techniques.

Being Smart

Alongside mystique, mayele, or boule, the English word *smart* is gaining ever-greater currency in Kinshasa. A website called Smart Congo and Facebook pages with the same title testify to this. Other African cities—and other nations—have also been "smartened." In Rwanda, the social network Smart Rwanda Days was "born from a dream to boost a culture of literacy and a passion for excellence," as its website says.[8] Smart Rwanda is a cooperation between the Rwandese government and Ericson. The initiative also organizes networking days, called *Smart Rwanda Days*, "to connect, innovate and transform" Rwanda. Smart Africa is a South African entrepreneurial initiative that—as its website claims—wants to "promote South Africa to its rightful place as a region of excellence and to further establish South Africa as a recognized contributor to the international IT and software industry."[9] The cooperation between Congo-Brazzaville and India is called Smart Congo and is centered on the establishment of a "smart public transport system."[10] In the DRC, "smart" initiatives are also being established; for example, a collaboration between various NGOs and high-tech enterprises has launched an interactive microsite freely available for use by anyone. Its goal is to provide alerts about elephant poaching in the DRC's Garamba national park, thus helping park rangers track ivory hunters via satellite imagery and predictive analysis.[11] All of these initiatives operate either on the level of the nation-state or internationally, and they literally borrow

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from the international language of smartness while also using cutting-edge digital, "high-tech" technologies.

From "below," however, the word *smart* (used in its English form) has different connotations, which evoke less explicitly the imagination of a future operated by highly advanced wireless technologies. Thus far, I have found two distinct ways that *smart* is used by Kinois. First, the *smart* label plays into the English connotation of beauty with the word *smart*. One example is the hashtag #SmartRDC that has been created early 2014 by Filip Kabeya, a thirtysomething IT practitioner living in Kinshasa, better known by his Internet pseudonym, Keyzer Soze. He set up the website kozangate.net in 2011, which was Kinshasa's first electronic nightlife calendar. In 2015, Kabeya initiated a coworking space for tech professionals (www.mtechhub.cd) and created Facebook groups such as Emploi en RDC/Job in Congo, Sortir à Kinshasa, and Kinshasa Professional Network. Job announcements are posted by members; members also advertise online goods that they sell either from home or only virtually (hair extensions, clothes, electronic devices). In the midst of these Internet activities, and crosscutting these various Internet platforms, Kabeya began using hashtags such as #ITPassion, #RDCTech and #allforDRC. The hashtag #smartRDC was inspired by concepts such as Smart Africa and Smart Rwanda,[12] Regretting that Internet infrastructures are not yet in place in DRC to allow people to live "smart" in a high-tech way, Kabeya invites people to post pictures under this hashtag that "show an infinitely beautiful DR Congo." By bending the English *smart* to indicate *beautiful*, Kabeya wants to instill a sense of pride among the Congolese by inviting them to construct a positive image of DRC.

Playing with the religious idea of knowledge and creativity, Kabeya claims that his pioneering initiatives in DRC's virtual world are the consequence of a "gift" (*likabu*). Jokingly, Kabeya defines himself as a *visionnaire*, someone who sees things that others do not yet see; as he observes, "people do not understand him."[13] Kabeya's inclination to contribute to a smart DRC is the outcome of his international involvement. After working for almost a decade with the German cooperation, Kabeya has lived in various African countries and traveled extensively within the continent and to Europe. Impressed by the fast technological developments in Rwanda in particular, Kabeya assumed that this should also be possible in the DRC. He continues to travel, even making special visits to Kigali to learn from their expertise in situ, and he aims to create a network of like-minded people who all are passionate about advanced technologies and want to live with them.

The second way Kinois define *smart* is illustrated by Hugo Kuva, a private Congolese entrepreneur living Kinshasa but who often travels to the United States (Dallas, Texas, in particular, because of family ties). Kuva is not part of Kabeya's circle, though he also plays around with the *smart* concept in the Congolese digital world. In October 2012, Kuva created a private enterprise called Smart Congo. On the now expired website, Kuva explains to people the ways in which Smart Congo is smart:

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Smart Congo uses about 90% open source technologies in its web development. This practice allows the client to set himself free from paying additional license fees and utilize technologies in stable communities, thus allowing an easy-take over by a third developer. ...

A manager and former freelance web developer with a very long career, [Kuva] brings together know-how and experience obtained here and there [*de gauche à droite*] for developing the company. (my translation from the original French on www.smart-congo.com, expired at time of publication of this chapter)

Significantly, Kuva explicitly announces that he is using open-source, free software, combining knowledge gathered "from here and from there." Being smart here suggests being resourceful, taking advantage of opportunities that are around the corner, in contrast to having followed formal or specialist IT training or using advanced high-tech-software. *Smart* here refers to cleverness in the Yankee sense. Like the 419 scheme conmen and other scammers (Apter 1999; Ndjilo 2008), Kuva cleverly uses the possibilities of the Internet to be an internaut and enrich himself. Although in contrast with Internet frauds, Kuva achieves this aim without transgressing moral codes.

The invention of the first African smartphone, *Elikya*, by IT specialist Verone Mankou is a similar way of being *smart* in the IT world while flirting with the line between the moral and the immoral. Mankou traveled to China, where he visited factories that produce parts for Samsung, Apple, Nokia, and the like. Mankou negotiated contracts with these factories, assembling a mobile phone that he later promoted as "the first African smartphone." Although contestations have occurred regarding the *Elikya's* exact "African" content, as well as its originality, the smartphone demonstrates resourceful ways of creating something new out of existing things, making big money, and becoming famous. Repackaging inventions made by others in an ingenious way turns Verone Mankou, the Internet scammers, and Kuva into tricksters. Tricksters in Congolese oral culture have always been male, young, cunning, and smart, and they often break social and moral rules temporarily. Ultimately, Kuva and Mankou are not breaking the rules—although they are flirting with the borders between originality, copying and piracy, and they are appropriating the concept of *smart* in a way that allows them to better achieve their goals. In a high-tech context, their usage of *smart* is closer to the second meaning of *mayele* (discussed at the beginning of this article) than to the English definition of *smart*.

Other examples of being smart with information and communications technology (ICT) is the constant juggling of multiple mobile phones, or mobile phones with multiple SIM cards, so that users do not lose too much money by making phone calls to other networks. Smart ways of circumventing political constraints within the mobile phone culture are also arising. In January 2015, the government shut down Internet traffic, thus making it impossible to communicate over social media with fellow Congolese or people abroad. This inconvenienced *commerçants* (merchants) in particular, who operate through telephone and email conversations with middlemen abroad. During the weeks that Internet traffic was blocked, one anonymous *commerçant* spent his mornings on a terrace close to the Congo River, where his smartphone picked up the signal of a cellular company of the other,

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neighboring Congo. Similarly inventive ways of circumventing state blockage of electronic communication were also used in December 2011, when the state blocked text message communications during the weeks before election results were announced. Congolese bought SIM cards for neighboring countries and sent international text messages to fellow Congolese (see Pype 2016b). These observations show how urban authorities are never fully in control over their citizenry and that technological spaces allow for slippage. Political control over the technoscientific is never total; citizens will find ways of dealing with limits imposed by authorities.

However, everyday smartness should not be read only as a reaction against economic or political constraints. Rather, as Steel (forthcoming) shows, gender-related forms of immobility can also be circumvented by using ICT in smart ways. Steel's ethnography of married Muslim women in the city of Khartoum describes how these women carefully negotiate their reputations and economic independence in a society that strictly locates them within the domestic sphere. Selling goods online via social media platforms such as Facebook and Whatsapp is an activity that allows these women to maintain their social and moral integrity while also earning money and staying in the living room. These and the other ways described previously in which Kinois and others are smart are just some of the many ways in which residents of African cities counter the economic, social, and political limitations of their mobility.

Conclusion: Scales of Urban Smartness

In this chapter, I paid attention to technological practices and discursive utterances regarding smartness, intelligence, knowledge, creativity, and innovation. Taking a dictionary entry as an example of how meanings can coexist and explain the same phenomenon, I have explored linguistic forms and their connotations. A term such as *mayele* and its synonyms—all closely related if we think about the interactions between technology and society—circulate in different social circles, which are in turn connected to local and global worlds in varying ways. Such vocabularies express different scales of connectivity. As a result, I had to link discourses observed in Kinshasa with ethnographies about ethnic Congolese groups and with Kinois newspapers and websites managed in London and Johannesburg. This suggests that *innovation*, *smartness*, and *creativity* are floating signifiers, filled in depending on who uses them, on the objects with which they are connected, and on their (imagined) users. This methodology allowed me to introduce a heterogeneous image of life in Kinshasa, and it has helped me unravel the various ways in which one can "be smart in a city," with or without being wired or investing in high tech.

The first scale I identified was the international sphere, dominated by the West and appropriated by the Congolese state. The promotion of innovation and the encouragement to Congolese youth to "innovate for the future" are embedded within an international, Western-centric scale of high-tech speak from which states borrow. The usage of the French

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innovation literally shows the international scale within which these activities should be situated.

This chapter also concluded with the same international scale, now focusing on the concept of being smart. However, here it seems that it is not only state officials but also Kinois themselves who appropriate what it means to be smart. Here, I referred not only to international, NGO, and tech companies, but also—and maybe especially—to ethnographies of urban sociality. The city itself, a postcolonial urban environment with its particular forms of sociality, has become a second scale of reference; it is a site that generates new forms of knowledge and technological enhancement. The Kinois usage of *smart* is closer to *boule*, which summarizes the informal, maybe even immoral type of street knowledge that urban livelihood in African cities demands. Yet as suggested by music TV shows, in which the elderly dance and speak about the origins of the city, smartness can also derive from the present-day currency of distant pasts. The scales crosscut the semantic fields of innovation and technology in Kinshasa, and thus stretch over space and over time.

Finally, understanding the logics of technology and the possession of a certain expertise over this technology through the idiom of *kindoki* unsettles received ideas about intellectual property, knowledge transmission, training, and even the social positioning of technology experts. But here also, the city as a scale in itself is imbued with this type of knowledge production, because street smartness is close to the mayele of tricksters and diviners.

By bringing to the fore the heterogeneous ways in which Kinshasa's residents deal with technological infrastructures and attach value and meanings to those who handle technological equipment and by embedding these ways within discourses about knowledge, creativity, and urban skills, my goal was to rethink what it means to be smart in the city. As mentioned, the concept of smart cities seems to be reserved for global cities such as London, Singapore, and Melbourne. Although many cities in the global north are trying to become "smarter" by integrating more high-tech and wireless technological infrastructures into public services, the stereotype remains that African cities are not "smart." Despite the emergence of a "smart village" in Cairo (see Mitchell 2002; Ghannam 2002), the plans for Konza Technology City in Nairobi, and similar initiatives elsewhere, it remains inconceivable to associate technological innovation with African cities. Furthermore, these "smart centers" in Rwanda and Egypt are enclaves, dominated by Western ideas of infrastructural progress and futurities. In this chapter, I have taken the opposite perspective and attempted to see how in Kinshasa's streets, households, markets, and hotels, Kinois engage with technologies, how they combine various registers of expertise and creativity, and how these in turn combine to produce variegated ways of being smart in the city.

By listening attentively to one radio host's ideas about techne and observing the social reputations of ISTA students, musicians, and IT developers in the city, a perspective of "smartness from below" has emerged. Although the "amateur" radio practitioner on one hand and the engineer-in-training who has received formal schooling on the other might seem to occupy two poles on the continuum of expertise acquisition in the field of modern

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technology (with those who use social media somewhere in the middle), both positions are embedded within local approaches to knowledge acquisition and information possession.

In addition, through this material I have shown that the study of technology transfer in Africa needs to take the socioreligious contours of innovation (*kosikola*, in verb form) and knowledge (*mayele*) into account (see also Mavhunga 2014; chapter 2, this volume). An analysis of what technologies such as radios, mobile phones, and television do in African societies should go beyond the study of social mobility, development, and change, or even "modernization." Rather, we should try to understand how these technologies relate to indigenous knowledge. New types of experts, expertise, and authority come about with the appearance (transfer/production) of new tools, thus bringing about new dynamics in society. New forms of social distinction, competition, and experience emerge when novel material goods are introduced (by local producers or by brokers). Yet, however new these may be, such *new* types of knowledge and experts do not appear in a social vacuum devoid of other types of mastery, erudition, and skills. We need to situate these new "technology experts" among the other types of masters and specialists upon which they draw or with which they contest or compete. If we want to take technology in Africa seriously, then we need to study how doctors, professors, and healers (all nganga), as well as blacksmiths and radio practitioners, computer engineers, and robot experts, within the same society relate to their tools, acquire their skills, and converse with one another. This dialogue can be convivial, aggressive, or subtle and can go in all directions, leading to either collaboration or destruction among the various experts—yet cohabitation is found therein for sure.

The spatial and temporal coevalness of the various scales I describe is important. Taking up the model of the dictionary entry once again, we can think about how some denotations attributed to a word may sound archaic or anachronistic, whereas others may receive the label *foreign*. Yet the meanings explored in this chapter all come together when we think about smartness in relation to technology in *contemporary* Kinshasa. It takes a social scientist to carefully observe and listen to the gestures and words of those who are working with technology and to allow for semantic, social, and technological complexity, irreducible to one single form or meaning. In other words, the challenge is to remain attentive to the polysemy of technology, innovation, and creativity, as well as the contiguity of meaning, practices, and experts.

Notes

1. The original document contained a typographic error; it read "This invasion" instead of "This invention."

2. Similar observations have been made elsewhere on the continent; for example, in Kasenaland (northern Ghana) diviners' bags, you can find batteries, audio tapes, covers of mobile phones, radio antennas, and the printed circuit boards of secret machinery (Cassiman 2013).

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3. Yet among certain Congolese groups, blacksmiths also are figures of reconciliation. Because their working space becomes a place where people gather, blacksmiths have knowledge of people's grievances. Such knowledge can be used to restore harmony among people.

4. In mid-August 2014, the house of a friend of mine was burned down by ISTA students. A few months before, an ISTA student had started going out with the girlfriend of my friend's brother. His brother challenged the student by exclaiming: "Wait and see. He can't get away with this just because he's an ISTA student!" Unfortunately, his warning triggered the aforementioned violent reaction from the ISTA community.

5. Interestingly, a Kenya-based website describes Docteur Nico as a guitar wizard: http://www.africareview.com/Arts-and-Culture/The-rise-and-fall-of-TP-OK-Jazz/-/979194/1416534/-/78ruxmz/-/index.html.

6. Facebook (Messenger) interview from May 14, 2015.

7. I thank David Kerr for reminding me of Dar es Salam's nickname (personal communication, May 23, 2015).

8. See http://smartrwandadays.rw.

9. See http://www.smart-africa.com.

10. See http://www.temoignages.re/international/monde/250-millions-de-dollars-de-l-inde-au-congo,67889.html, a remediated newspaper article dating from June 20, 2013.

11. See http://allafrica.com/stories/201501301227.html.

12. Facebook interview from May 14, 2015.

13. Facebook (Messenger) interview from April 25, 2015.

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6
On the Politics of Generative Justice: African Traditions and Maker Communities

Ron Eglash and Ellen K. Foster

Our understanding of political economy has been strongly influenced by two models: the free market economy of private ownership and the socialist vision of government ownership. The socialist vision is one that calls for distributive justice—the top-down redistribution of wealth. Its application in the USSR was a humanitarian and ecological disaster, so it is no surprise that African socialism did not fare any better. Similarly, the free market approach has resulted in the alarming acceleration of wealth inequality, unsustainable extraction of natural resources, and environmental disasters on a global scale. Rather than import these failed models from European roots, it is our contention that a better framework for egalitarian and ecologically sustainable societies lies in African indigenous traditions—a framework we refer to as *generative justice*. However, this is not to imply that Africa needs some sort of cultural purity; generative justice can be seen in many forms throughout the world. One of the primary exemplars for contemporary generative justice has been the maker movement, and for that reason we focus on African maker communities in this chapter.

The generative justice wiki defines generative justice in the following way: "The universal right to generate value and directly participate in its benefits; the rights of value generators to create their own conditions of production; and the rights of communities of value generation to nurture self-sustaining paths for its circulation."[1]

Generative Justice in African Traditional Society

The concept of value generation is at the core of many African spiritual beliefs, where it takes the specific form of a *self-generating* or recursive flow of unalienated value. This is distinctly different from value generation in other frameworks. Capitalism mistakenly views money as a self-generating value form, as though two dollar bills left alone in a bank vault will spontaneously give birth to a baby dollar bill. We constantly use terminology like "your investments will grow" or "a thriving bank account" that reinforces this illusion. However, these are alienated forms of value extracted from elsewhere. Rejecting industry altogether and valorizing the "natural" over the "artificial" is no better. Consider, for example, Uganda's

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consideration of the death penalty for the crime of "unnatural sex." Or consider the romantic organicism in some environmental movements; for example, Earth First! founder David Foreman publicly recommended allowing Ethiopians to starve to death during the 1980s famine as a way of allowing the ecosystem to return to a "natural state" (Bookchin et al. 1999).

Traditional African concepts of self-generation, like those of many indigenous cultures, focus neither on extracting value for export elsewhere nor on elevating the purity of nature over culture. Rather, they depend on collaborations of humans and nonhumans in which value is 1) allowed to remain in nonextracted, unalienated forms and 2) *circulated* from the bottom up. In Africa, this generative recursion has many different symbols, but one of the most vivid is the West African icon of a snake biting its own tail (figure 6.1). There are two underlying principles at work in this circular flow. One is what engineers might model as negative feedback: preventing greed, value hoarding, wealth inequality, or other dynamics from extracting value. This is well-visualized by a Baule carving in which each crocodile has the other's tail in its jaws; it is said to represent "the chief and the people in balance"(figure 6.2). The other principle is what engineers might model as positive feedback: a self-expanding source of value, sometimes disruptive or even chaotic, as we see in a second Baule carving, said to represent "the cycle of life" (figure 6.3).

Negative feedback is the force of stability. In African iconography and spiritual descriptions, it is the force which is said to drive cyclic phenomena: calm waves in water, the sinuous motion of an animal, the turn of seasons, and so on. However, these African depictions

Figure 6.1
A traditional African symbol of recursion, this snake biting its tail appeared on the palace walls of the kingdom of Dahomey (now the Historical Museum of Abomey).
Source: Ron Eglash.

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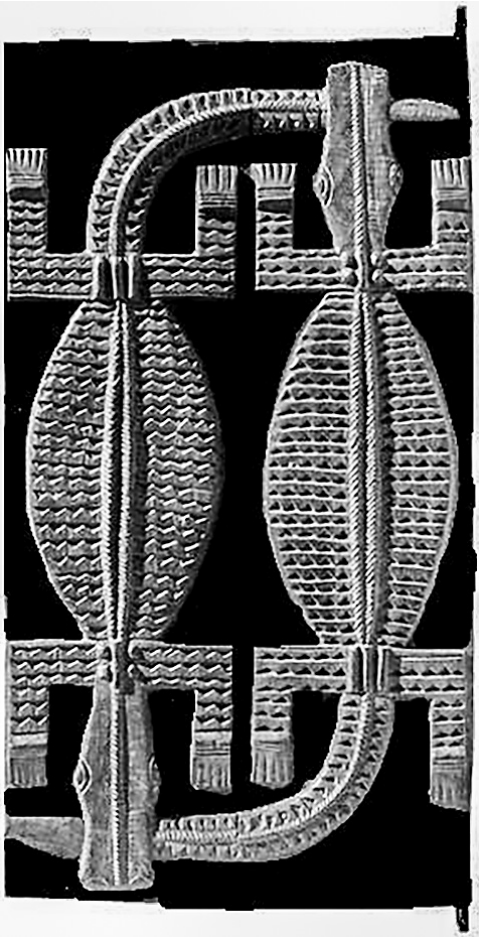

Figure 6.2
Baule carving, "The Chief and the People in Balance." The background has been darkened for greater visibility.
Source: Hamill Gallery, Boston.

of cyclic phenomena have been isolated in Western descriptions and thus form an incomplete and misleading portrait. The concept was first appropriated by colonial anthropology's need for images of static, rule-bound traditionalism (Shaw 1995). Later, it was applied by politically conservative forces, such as in Disney's *The Lion King*, in which the "great circle of life" justifies the lion's inherited nobility and the hyenas' banishment as welfare cheats (Giddings 1999). Missing from this portrait is the opposing force: the positive feedback of a destabilizing, creative, chaotic trickster—sometimes responsible for unfortunate random events,

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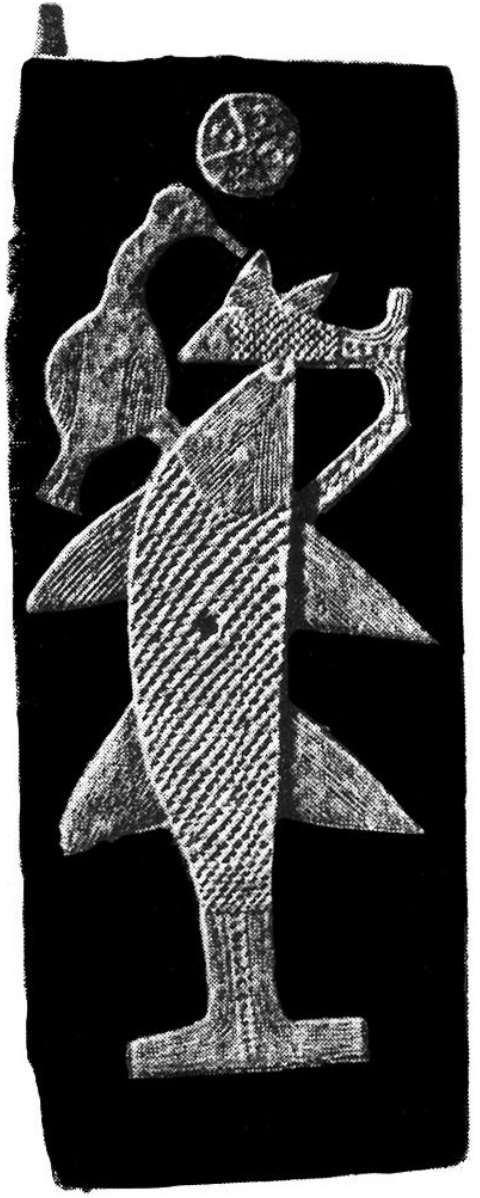

Figure 6.3
Baule carving, "The Cycle of Life."
Source: Ron Eglash.

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but also fundamental to imagination and innovation. Just as modernism appropriated the cycle, postmodernism valorized the trickster (Eglash 2003).

It is only when we see how stability and instability are coupled that we can grasp the system as a whole. Figure 6.4 shows this pairing across different African cultures; the best known in the West is Dan and Legba in the Vodun religion, which is still practiced by about thirty million people in the West African nations of Benin, Togo, and Ghana and which gave rise to syncretic religions such as Voodoo in the Caribbean and Brazil. That is not to say that there is some sort of homogeneous cultural unity across all of Africa; the theme of self-generation of value arises in many different ways and forms. However, this spiritual structure is strikingly common: pairs of lower gods that embody complementary forces of order and disorder, and a distant "high god" whose life force combines these traits, creating a fractal—the dance between order and chance.

Fractals are the self-similar patterns mathematicians use to characterize living structures: branches of branches in trees and lungs; folds of folds in brains and intestinal villi; clumps of clumps in tiny cell organs or giant coral reefs. Complexity theory, which is the science of self-organization, shows that these fractals arise from a coupling of negative and positive feedback. Indeed, the inverted U-shape in figure 6.4 is typical in complexity theory: The least complex at the extremes of order and disorder, the apex of complexity occurs for fractal structures at the center.

Fractal patterns are also typical of African traditional architecture. Western architectural traditions of top-down civil engineering spatially encode authority in ways that substitute elite expertise for democratic decision-making. In theory, engineers are imposing the features that will make life better for all, but these city layouts often act to preserve and reinforce the spatial power of the wealthy (Bickford 2000)—hence phrases such as "born on the wrong side of the tracks." In contrast, the bottom-up traditions of African village layouts often support bottom-up decision-making and hence more egalitarian economic and environmental structures. Caplan (1981), for example, studied the relation between housing and women's autonomy in Tanzania. She described how the flexibility of housing allowed women to create new homes if they wanted a divorce or to extend old homes if they wanted to shift the family structure. As in many traditional African settlements, this self-organized housing allowed for greater social control by women. When socialism led to modernization programs, this autonomy was threatened by "improved" housing designs, which sometimes resembled concrete army barracks.

This traditional self-organization often results in self-similar spatial patterns: fractals. For example, in a fractal model of a Ba-ila village in Zambia (figure 6.5), we can see (a) a single ring-shaped house with the sacred altar toward the back; (b) the ring of rings with the human habitation toward the back forming a corral; and (c) the ring of rings of rings forming the village as a whole. At the center of the final shape (enlarged at right), the chief's extended family surrounds the chief's immediate family, which surrounds a tiny model village in which spirits of the ancestors reside. The relation between these scaling rings is described by

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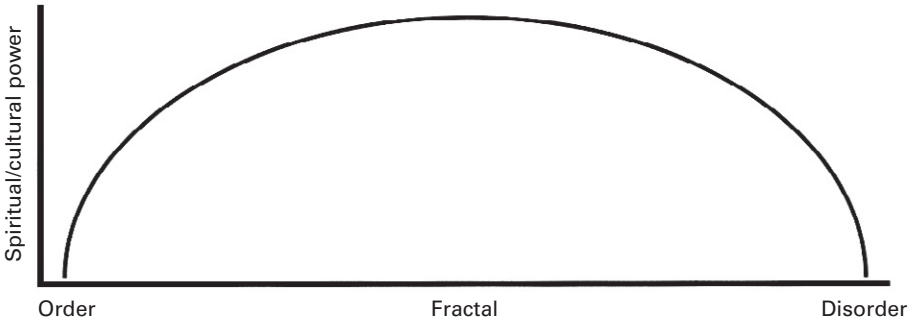


Akan (Ghana):

Icon for "calm waters"

Nyame's power of life; turbulent waters of Tanu

Ananse the trickster

Vodun (Benin, Nigeria African diaspora):

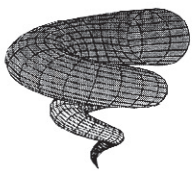
Dan

Mawu (acts through lower gods, e.g., the bifurcating doublings of Shango)

Legba, Eshu the trickster

Dogon (Mali):

Nummo (drawing based on photo of ritual staff in Imperato 1978)



Amma (described as an expanding spiral, like a whirlwind)

Ogo the trickster

Figure 6.4
The mapping from ordered to disordered phenomena in African spiritual traditions.
Source: Ron Eglash.

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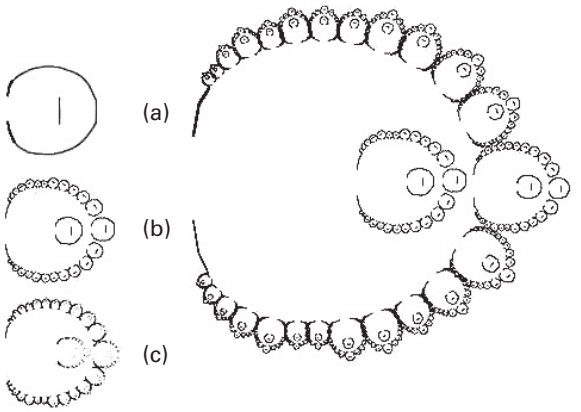

Figure 6.5
Fractal model for Ba-ila village in Zambia: (a) single house; (b) family enclosure; (c) village as a whole. *Source:* Ron Eglash.

the locals as *kulea* (to nurture; Eglash 1999). This sense that ancestors nurture the current generation is another way to enforce intergenerational responsibility (reflected in religious obligations to ancestors, economic obligations to elders, etc.). It includes both positive feedback—fecundity and other forms of value generation—and the rule-bound negative feedback that prevents the system from creating the concentrations of wealth and power that plague capitalism.

These traditional fractal structures, created by a "nurturing" combination of negative and positive feedback, are not a utopian garden of Eden; like any other human organization, it is full of all the usual petty human failings. However, centuries of trial and error—discovering which practices cause environmental degradation and what conflict resolution works best—result in a basin of attraction for generative justice (Eglash and Garvey 2014): the gradual evolution of agreed-upon rules that allow those who generate value to have a say in its circulation. A well-documented example is the *hxaro* tradition among hunter-gatherer groups in the Makgadikgadi (meaning a very dry place, corrupted to Kalahari Desert by European travelers): Meat belongs to the maker of the arrow, not the one who shot it. Because women can make arrows, even those who do not hunt are credited with the kill. Thus, gender relations have an economic basis for an egalitarian structure. Mavhunga (2014) makes the case for a wide variety of such communal characteristics in African traditional hunting practices, but he also points out that these traditions of generative justice did not simply evaporate in the face of either colonialism or "modernization" projects: Communal traditions in hunting were both adapted and appropriated during colonial and postcolonial eras. Similarly, fractal architecture is now enjoying its greatest expansion in the African context (May 2013).

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To summarize, colonial characterizations—still with us today in the form of romantic organicist movements—tend to view the environmental and social sustainability of indigenous societies as an unintentional consequence of living "closer to nature"—of less cognitive reflection and more intuitive action. To the contrary, these forms of generative justice evolved over centuries of conscious reflection and developed their own internal models for maintaining an awareness, however deeply encoded in symbolism, for balancing sustainability and change. In the next section, we turn to the maker movement as the latest instance in which the African generative justice tradition is reinterpreted through contemporary materials and practices.

Generative Justice in Contemporary Sociotechnical Movements

In the West, two models have reigned supreme: the free market model that emphasizes innovation from wealth concentration and the socialist model that makes similar assumptions regarding the need for top-down distribution. Both commit the same error in assuming that bottom-up systems result in a tragedy of the commons, which only privatization or state authority can resolve. However, many contemporary sociotechnical movements have proved this contention wrong. Open-source computing is one of the best known of these "bottom-up" systems: a kind of "communal" exchange of labor value in which thousands of volunteers contribute to code that is legally placed in the public domain. Open-source founders such as Eric Raymond made the explicit connection to indigenous societies, as evidenced by Raymond's 1998 essay, in a section titled "The Hacker Milieu as Gift Culture," where he notes: "We can observe gift cultures in action among aboriginal cultures living in ecozones with mild climates and abundant food."

We can compare the typical flow of value under socialism or capitalism to that of generative justice by using the flowcharts in figures 6.6 and 6.7. Figure 6.6 shows how labor value is normally extracted: profits go to the state under socialism, or to factory owners under capitalism, but typically little is returned to workers in either case. Figure 6.7 shows a value flow chart for one of the paradigmatic generative justice examples: an open-source hardware device called *Arduino*. We have diagrammed the arrows showing unalienated value with double lines, as if the value being transferred were an embodied fluid moving through a pipe rather than an abstraction transmitted by wire. Rather than patent the circuit, the inventors of Arduino use an open-source license, which puts the intellectual property rights in the public domain. Anyone can download a blueprint, make whatever changes they like, and sell the new device themselves. And the software these circuits run is also open source, part of an enormous community in which both professionals and amateurs share their code with no strings attached.

It is by no means utopian: Because the Arduino is partly hardware, there must be a physical component, and in this case it is fabricated in factories and bought and sold like any other capitalist commodity, as in the loop on the left of figure 6.7. However, within the loop on the

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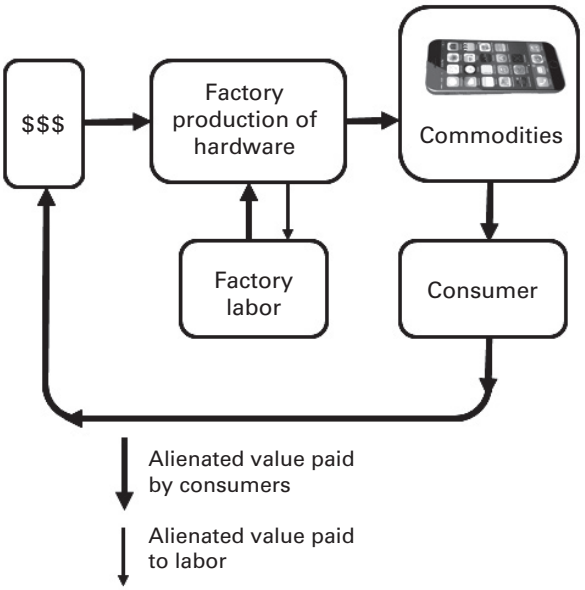

Figure 6.6
Value flow under socialism or capitalism.
Source: Ron Eglash.

right, there is a remarkable gift economy at work. As of 2014, about 1.2 million of the official boards had been sold, and the number of applications for the board is almost as large, ranging from whimsical gadgets to innovations for disability (McAllister, Yuen, and Bush 2012) to citizen science for pollution detection (Gertz and Di Justo 2012) to low-cost health electronics for low-income communities (Monicka et al. 2014).

In the case of Arduino's code sharing, there is little conflict, because each piece of code runs independently. However, even in large-scale open-source projects in which code must be unified, these conflicts can be resolved without top-down authority. Although older contributors often have more authority in deciding what code is incorporated, newcomers—contributors at the bottom—can always "fork" the code and simply start their own projects. Like the Baule door carving of two crocodiles each with the other's tail in its mouth, this negative feedback prevents authoritarian abuse in labor structures and ensures a push toward cooperation from all sides. The pairing of positive feedback for innovation from these computing communities and negative feedback made possible by open source's balance of powers is what makes generative justice recognizable across both the indigenous and information technology domains (Eglash and Garvey 2014).

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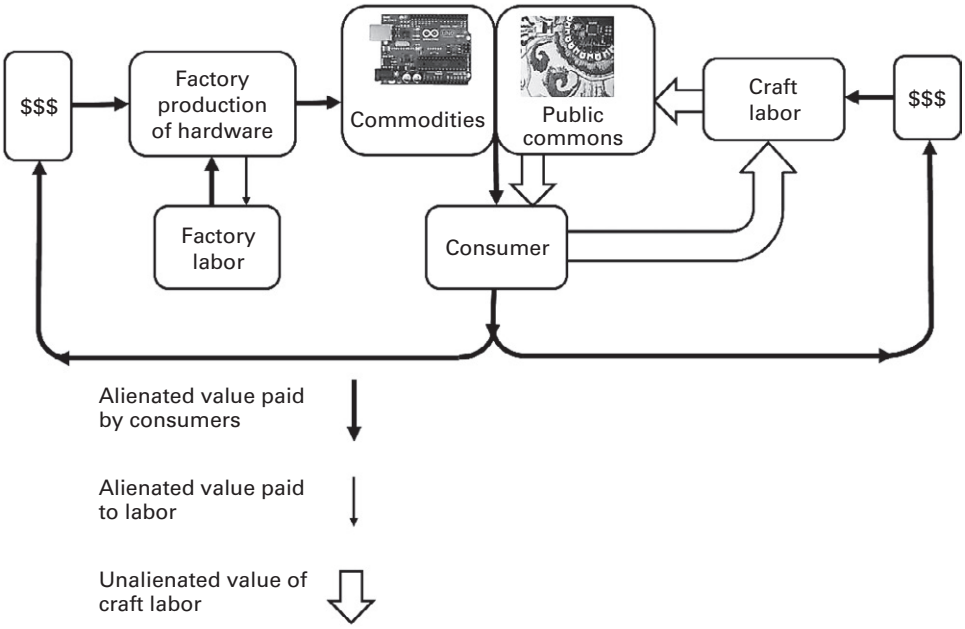

Figure 6.7
Value flow in the Arduino community.
Source: Ron Eglash.

In the case of organic gardening, this recursive circulation also applies to nonhumans as generators of value. When software developers say they want to release their code as open source rather than have its value extracted, they are saying that the value of the code they generated will now circulate in a community of developers, and that they make this choice because they can assume that others will do the same. If a plant could say it wants to recirculate the value it has generated, rather than have it extracted, surely it would mean it wants to decay and enrich the soil for its progeny, establish a gift exchange with bees (the value of nectar and the value of pollen distribution in common circulation), offer us their O_2 for free on the assumption that we will continue to contribute our valuable CO_2, and so forth. Combined with human agency, this productivity is expandable. Contrary to Marx, there is nothing that inherently limits the productivity of such unalienated value circulation to what he called *Natur-bedurftigkeit* (nature's stinginess). We can keep value in unalienated forms and still leverage its productivity with technology: for example computational approaches to organic gardening now allow a combination of old-fashioned natural plant breeding with information technology for tracking desirable traits (Manning 2004).

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A Brief Introduction to Maker Movements in the United States

Maker and hacker practices in the United States are characterized by certain social formations and affinity groups, and may culminate in the physical instantiation of a *hackerspace*, also known as a *makerspace*. These are often group-owned and group-funded spaces in which like-minded individuals can meet to explore interests in hacking, making, and fabricating in a fairly general sense. The first hackerspace was probably c-base, initiated in Berlin in 1995, but hacker/maker culture soon proliferated throughout the United States and Europe, brought about by joint global conferences such as the Chaos Computer Conference (Toupin 2014).

Hackerspaces/makerspaces now populate all continents, and the "maker movement" has been characterized as a transformative and global phenomenon (Anderson 2012). Practices shared can include soldering, simple circuitry, using woodworking and metalworking tools, knitting, sewing, and many more. The communities out of which these material practices and spaces grow often situate intent and point toward the need for particular tools or shared skills. There is a focus on communal sharing of not only tools, but also knowledges and access to different forms of knowing. One category of makerspaces, such as the TechShops chain, are more innovation-driven and geared to help start-up businesses perform simple prototyping and fabrication; others are focused on enrichment and educational opportunities (for example, makerspaces located in public libraries); still others have a more politically and socially minded theme, questioning gendered practices and consumer culture (Liberating Ourselves Locally in Oakland, Femhack in Montreal, and the Fixers Collective in New York City, for example).

The maker movement is not without its critics, who point out that its bottom-up characteristics are often accompanied by top-down and consumerist-driven initiatives. DARPA, Microsoft, Intel, and other corporations find interest in its energy and endeavors for technological innovation (Morozov 2014, yet on-the-ground activities and more socially minded groups show that grassroots approaches are still profoundly in play. One particular group, the Fixers Collective (based in New York City but also active in Seattle and Portland), is interested in maintaining and caring for objects rather than disassembling them for component parts, which is the general practice among hackers and makers. The US-based Fixers Collective has a European counterpart in Repair Cafés, which are also communally and socially driven (Charter and Keiller 2014).

Makerspaces in Africa

Fixer practices are also quite prevalent in African countries—not as a political rebellion against planned obsolescence, but rather due to economic necessity: the expense of new devices, the paucity of products or even replacement parts, and the need for a means of employment. This puts hacker and maker practices in some African countries at an

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interesting juncture, as "making do" craft skills and economic necessity intersects with the democratizing politics of questioning top-down technosocial practices and informing innovation. The fixer sides of maker/hacker cultures are geared toward regenerating value in objects on a local scale. This side is prevalent in two of the African sites we visited in Ghana, the Creativity Group in Kumasi and the QAMP group in Accra, as will be discussed shortly. Similar to the findings of Foster's work on US hacker and makerspaces (Foster 2015), these groups and others in Africa have complex ecologies, politics and cultures.

For the purposes of this chapter, we will focus on African makerspaces, which have been accelerating in popularity and prevalence across many different countries and groups. Although they align themselves under the general ethos of bricolage, skill sharing, and creative collaboration among those with many different interests, they are also locally and culturally situated. From preliminary research conducted in Ghana and our communications with other groups, places, and spaces, it is clear that the fixer mentality is far more deeply entwined with the fabrication and making mentality on the African continent than in the United States or Europe.

This became immediately evident in our conversation with D. K. Asare-Oseo of the QAMP project in Accra: He remarked that as soon as he first heard of makerspaces, he immediately recognized the African scrap yards populated by fabricators and fixers as their predecessors; he also noted a deeply entrenched cultural value around repair and making do with what is at hand. Contemporary cultural connections are also continually remade; for example, in reply to a question about ablution in relation to toxic waste exposure, D. K. noted that many of the poor working in Accra now come from Islamic roots and hence have a strong presence in the scrap yards.

Another example of generative traditions that blur both the fixing/making and traditional/contemporary lines is seen in the famous wire toys that can be found throughout the African continent. Davison and Skotnes (1986) note that analogous toys made from natural materials could be found prior to colonialism; for example, in southern Africa, bovine clay figurines were toys in traditional cattle herding cultures, in areas in which wire cars are found today. As locals shifted from pastoral to industrial economies, both the object of reference (from cows to cars) and the materials utilized in labor (wire for shipping, fixing, and other applications) shifted along with them. Peffer (2009) examines the prevalence of wire toy copies of the police trucks used in the brutality of apartheid surveillance and enforcement; in the context of DIY protest artifacts, children made these copies as a means to explore and in some cases gain a sense of mastery over their oppressors. Today, African wire toys can be found in many African nations; they have become so iconic that in some places their manufacture is largely for the tourist market. At the same time, they have become a part of international maker lore, appearing in *Make* magazine, *Afrigadget*, and other popular forums (e.g., see Brucker-Cohen 2009).

Cultural connections have also been noted in Senegal's Colobane market, where *se débrouiller* (making do) with repairs and salvaged materials can signify a collective ethos with

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spiritual resonance. Grabski (2014) quotes Colobane resident Aminata Diop: "'You know God has given the Senegalese people something, whatever we can see we can fix. Whatever we see broken we can make it work again.'" Schaller de la Cova (2013) notes that many Senegalese now use the term *Góorgóorlus*—the Wolof name in a comic of a family that is constantly making do—as an indigenous translation for "recycling, repairing, mending, reusing, scrimping, and stretching ... The world of *góorgóorlus* is one in which cracked plastic lawn chairs and calabash gourds are sewn together, not thrown away, where shoes are polished nightly because the dirt and the sand of neighborhood streets quickly dirties even the most shiny, rich leather with a coat of brown, white, or red dust" (224). The term plays on the noun *góor* (man/male in Wolof), and Schaller de la Cova suggests that the connection is implying the duties of a family provider to improvise in the face of challenges.

While the corner repair stores of the United States have declined to almost nonexistence, such that the fixers movement seems to be only possible as an offshoot of makerspaces, or at least a new flexibility made possible with contemporary electronics, this relationship may be reversed in Africa. Ghana in particular has a rich informal economy of street vendors who will sell new wares but also will fix cell phones, printers, and other electronics with complex circuitry. They learn their highly refined skills through attachments (or internships) and then aspire or move on to owning and running their own shops. In this vein, many self-described hacker or maker groups of Africa are geared toward preservation practices and the creative reuse of waste. They are simultaneously pulling the warp of innovation geared toward the future while also weaving in the weft of repair practices already deeply entrenched in their cultures.

This melding of a global maker movement with localized skills, knowledge, and mindsets opens rich possibilities. Repair cultures uphold an ethos of stabilizing feedback that works to keep waste at bay. Meanwhile, the positive loop of innovation, open-source technology development, and the establishment of makerspaces in which to gather and share ideas disrupts and creates new ways to think about and reinterpret the possibilities of repair and waste. The snake bites its tail; fractal complexities grow as one-to-one skill sharing builds up to small working groups, networked together as a makerspace or tech hub, and ultimately perhaps a community of makerspaces that shares materials, practices, and projects.

Case Studies

Although there is a vast number of IT startup groups, computer/technology sharing centers geared toward innovation incubation, and hacker/maker groups within African cultures, the focus in this chapter is on socially minded efforts that culminate in locally contingent practices. Instead of critiquing the role that corporations such as Intel and Microsoft have had in co-opting local economies and innovation development in Africa and Ghana specifically, we are working here to explicate what is happening on the ground as an emergent and at times even subversive phenomena.

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Unlike the homogenizing forces of corporate culture or government bureaucracy, the bottom-up growth of these enterprises ensures that their particular local character is not lost. The hackerspace WoeLab, which is located in Lagos, is world-renowned for creating a 3-D printer out of e-waste: a tool that would normally be out of the participants' price range, not to mention the challenges of importing a notoriously delicate device (Stevenson 2014). However, this is not a matter of sheer necessity; the tool itself is typically used in creative and even playful ways in makerspaces, and to create a 3-D printer using waste is by itself a subversively intelligent move that challenges the ways in which innovators in developing nations find their creativity censored or imprisoned by demands for practical application.

iSpace is located in downtown Accra and is a place for local creators and innovators to meet up and work on their projects using a collective space and some shared tools. It has been host to civic hack-a-thons, including a hack4good event in July 2014 that brought together individuals with expertise in computer programming, information technology, the medical world, and beyond to work on local problems within the field of medicine. The goal of the meetup was to have technologists talk to medical workers and determine their needs in terms of an open-source IT platform. The dialogues that transpired also made the technologists aware of different special knowledges to formulate helpful technologies for their local communities. The iSpace initiative is focused on building local economies, but is also invested in helping to foster alternative educational practices and skill sharing beyond these innovation endeavors (iSpace 2014). The iSpace initiative hopes to build skillsets and possible economies from the ground up to ensure local economic stability and growth, one hub at a time. The founders of iSpace, Fiifi Baidoo and Josiah Eyison, have IT and entrepreneurial backgrounds, and while they are supportive of both open-source code, they see community-oriented spaces built from the ground up—a kind of open sourcing of the built environment—as equally essential. There is a recognition across African countries of the importance of these places and their malleability for supporting various initiatives. Eyison is confident in the Ghanaian people's ability to create change from within and generate more value through creative practice, focusing on ground-up technological transformation instead of hoping for policy or governmental action from above to foster technological development.

There is, of course, a double-edged sword in the independence of these initiatives: A neo-liberal ideology would jump upon these programs as justification for withdrawing government support. However, once we start thinking of generative justice as orthogonal to the ideological spectrum, we can see how both conservative and liberal political perspectives can be held accountable for providing support. Meyer (2014), for example, notes that the issue of *net neutrality*—to prevent Internet service providers from charging variable rates depending on use or content—has attracted supporters at both ends of the spectrum. Research on policies for supporting generative justice—legal support for open source, institutions for fostering civic organizations, public use spaces, —and so on—is both unexplored and critical to advancing its spread.

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Tech Needs Girls is another Ghanaian, educationally focused group that speaks to the generative justice ethos and was working from iSpace for some time. Mainly based in Accra and Kumasi, Tech Needs Girls focuses on breaking down barriers to computer programming and IT education for underprivileged girls. Ruby on Rails workshops are taught by female mentors, pushing against the sexist mentality that women cannot navigate computers or should not be involved in technological development. Tech Needs Girls supports this endeavor by directly putting the technology in question in the hands of eager, driven young women who are typically not allowed such chances. The workshops are geared toward teaching girls to create technology and content that is contingent upon and inclusive of their own realities, giving them a voice and a stake in the value of possible technical manipulation and thus creating their own value educationally and otherwise.

Tech Needs Girls is also working to establish satellite organizations throughout Ghana. Instead of relying on bringing these practices into the formal classroom setting, although they would like to, they are currently working with local university students who want to be mentors and help start workshops and programs on their own terms. As Eyison of iSpace has noted, with the difficulties of instigating change at the top-down governmental and policy level, Tech Needs Girls recognizes that it is difficult to transform long-standing school bureaucracies. By helping to facilitate bottom-up and generative skill sharing and educational structures, Tech Needs Girls is empowering often marginalized groups, which can go on to teach greater numbers of girls, thus generating a network of support for innovation and skill sharing.

Another group that is socially connected to iSpace, albeit geographically distant, is the CoCreation Hub in Nigeria. Much like iSpace, the hub is dedicated to fostering local startups to bolster the local economy. It has a similar focus on skill-sharing and educational practices, ranging from proposing new online services to hacking experiments with open-source hardware equipment such as the Arduino. Although originally focused on LEGO Mindstorms for robotic educational practices, the group is considering a move to using the Raspberry Pi in afterschool activities (currently called "Bot Club"; see Bot Club, n.d.), because it is more affordable and malleable given its open-source software. More recently they held a two-day hackathon described on their blog as one that would "identify ways & build technology solutions leveraging social media for reporting and eliminating violence against women." Thus, while an emphasis on entrepreneurial practices among these groups gives them legitimacy to corporate donors, they also aspire to incorporate social critiques and educational practices that are locally contingent and invested in how future local economies might grow and sustain themselves.

The Creativity Group is based out of Kwame Nkruma University of Science and Technology (KNUST) in Kumasi and cofounded by two KNUST alumni, Jorge Appiah and Papa Kwadwo Wonkyie Mensah, but it is fully run by currently enrolled KNUST students who control the direction and flow of its projects. The Creativity Group is focused on creating appropriate and sustainable technologies out of available parts, typically from e-waste. Often, these technologies have educational merit, are open source, and focus on fostering

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knowledge sharing and on hands-on learning. Cross-disciplinary collaborations are uncommon at KNUST, but Creativity Group members come from many different academic backgrounds and are invested in learning different skillsets from one another through the desgin of innovative and value-creating technologies. Appiah and Mensah created this group as a grassroots endeavor to avoid the specialization pressures that would come with formal institutional status such as an academic department.

Some of the Creativity Group's projects include an educational student kit (ESK), High Altitude Balloon in Testing (HABIT), and raising awareness of problems involved in e-waste disposal practices (Creativity Group 2013). They have also engaged local Kumasi communities beyond the university, and many members have partnered with fabricators working out of *Suame Magazine*. *Suame Magazine* is a marketplace for acquiring second-hand parts and is home to many machine-technology fabricators and fixers who have acquired their skills through attachments beyond or instead of a formal engineering education. Other projects and studies are also being conducted to create more interaction between university engineer students and traditionally trained informal sector fabricators, with initiatives reaching as far back as the 1980s (Waldman-Brown, Obeng, and Adu-Gyamfi 2013).

Similarly, the AMP (Agoblogoshie Makerspace Platform) group brings many knowledges, practices, and local issues into play for its project. The group helps to foster more sustainable (both economically and environmentally) scrapping techniques within Agbogbloshie, a waste and informal scrapyard site located in downtown Accra. To say the group uses "bricolage" is not quite correct; as this term was introduced by Levi Strauss as an analogy to the "handyman" who is meeting preset goals with improvised materials. The AMP process is far more strategic; moving between planned blueprints at one end of the spectrum (founder D. K. Asare-Oseo is an architect) and allowing the "found" material to suggest its own uses at the other end. The AMP group is creating a platform or vehicle for something we have termed *generative waste*.

Generative waste applies the concept of generative justice to the socially viable possibilities coming out of waste regimes. Tying into the Fixers Collective's push against planned obsolescence, this conceptual and methodological framing works with what one might consider marginal material to create possibilities for new networks and new systems of use. It also invokes Haraway's (1991) work in complicating the nature/culture/machine divide and Alaimo's (2010) "transcorporeality" by recognizing that, in the end, we become waste and waste becomes us as we move through and interact with it on a daily level. In this vein, AMP is working to generate further cultures, economies, and possibilities for education through remediation practices of a hazardous site—cycling through waste for positive feedback in a space that is based upon the negative feedback of trying to mediate, lessen, and repair waste that has been thrust upon it. While instigating new practices, the group works with scrapping communities that have been located in Agbogbloshie for ten to twenty years, planning a future *with* instead of *against* their needs. Already, the working group has helped to explore new ways to extract copper from cables and wiring and safe forms of plastics processing on site (AMP 2015).

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This is not to romanticize the e-waste site at Agbogbloshie. Clearly, greater systemic mechanisms must change in order to fully ameliorate the situation within its geographic bounds and beyond. The environmental hazards are not trivial, something which the AMP group hopes to bring attention to and map (Caravanos et al. 2011; Osseo-Asare and Abbas 2015). Yet by tapping into maker/hacker and community-driven knowledge-sharing practices, the co-principal investigators of the AMP initiative (D. K. Osseo-Asare and Dr. Yasmine Abbas) are working in conjunction with local students and scrappers to reform the landscape and improve its viability as a safer and more fulfilling work site.

They also hope to bring attention to practices such as those at the Agbogbloshie site and *Suame Magazine* that have always been in the realm of making, hacking, and repair, even before the so-called maker movement was established. Osseo-Asare asserts that it is all well and good that other hacker/maker groups are interested in bringing outside technologies such as MakerBots and Arduinos into the mix of possibilities, but they also need to recognize the long-standing, innovative fixing and making traditions already established in Ghana. For them, the idea that a maker movement is coming from outside of Ghana and is aiming to transform its landscape is highly problematic. "The problem is it continues to reinforce the mentality ... that all of the amazing things need to be brought in [from outside of Africa]. There [are] already makerspace[s] in Ghana ... let's see them as makerspaces and bring them into the discourse and not just focus on the negative side but try to use the positive side to change the negative side" (interview with D. K. Osseo-Asare, July 2014).

In AMP's current work, the group has illuminated the social and cultural aspects of Agbogbloshie and are invested in helping local scrappers realize their desires to create more business and stability, often through local processing and fabrication techniques. Osseo-Asare and Abbas hope to facilitate this through "inter-class innovation" (interview with D. K. Osseo-Asare, July 2014). Similar to Creativity Group's interdisciplinarity, the AMP group is working to foster inter-class collaborations between Ghanaian college students graduating in fields of STEAM and scrappers with highly refined material expertise in order to rethink the landscape of Agbogbloshie. Although still in its inception stage, the group has started using scrap and waste material from Agbogbloshie itself to create makerspace hubs for on-site educational and fabrication practices that are neither subservient to solutions from outside nor ignorant of current technological developments. Considering that there are long-standing fabrication groups such as a blacksmith and pot-fabrication collective within Agbogbloshie, AMP has a striking opportunity to facilitate a new synthesis between international developments in innovation and the creation of more locally formed, locally contingent, and locally led maker groups.

Conclusion

In the 1950s and 1960s, leaders such as Nyerere in Tanzania and Senghor in Senegal attempted to map African traditions into a Marxist-inspired framework and to implement this system

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in their developing nations. This African socialism failed not because of corrupt individuals, but because it was the wrong mapping in the first place. As Mbah and Igariwey (2010, 56) note in regards to the Ujamaa movement in Tanzania: "Whatever the peasants produced was sold to the authorities, and the government controlled the prices. In this way, the state squeezed the peasants for as much surplus as possible. It would have been simply unthinkable to imagine that Ujamaa, in its original, undiluted form, would have succeeded as part of a state system. To that extent, its failure was logical and inevitable." Squeezing the peasants for surplus is a common feature of both capitalism and socialism; all systems that put a premium on value extraction will put their value generators—whether human or nonhuman—at risk of failure to return that value.

We can think of the spectrum of political economy as a horizontal line, with a pure free market at the far right and pure communism at the far left. Generative justice, in contrast, is *orthogonal* to that spectrum; a y-axis to the horizontal range of ideologies. For example, in the case of communism, both labor and nature are (rightly) considered true generators of value. However, the value generated by labor and nature has to be *extracted*, just as it was in capitalist societies. The only difference from capitalism was that the extracted value would be "returned" to the people by the state (figure 6.6). This return of value has failed miserably in most attempts. Extracting nutrients from soil and attempting to return them in "alienated" forms of value—chemical fertilizers and pesticides—creates environmental damage. Extracting labor value and attempting to return it in the form of "the people's factory" is no less alienating than when capitalism extracts labor value. The Soviet Union, for example, was notorious for widespread poverty, environmental degradation, paranoid militarism, and the destruction of civil rights. Neither communism nor capitalism have a good record in the attempt to return extracted value to labor and nature. Rather than rely on extracting value and returning it in alienated forms via distributive justice, it is our contention that social equality and environmental balance can best flourish when structured by generative justice, which seeks to *avoid value extraction in the first place*.

It is obvious why capitalism would want this extraction: Its free market model requires that workers sell the only thing they have, their labor power, and that the "forces of production" (Noble 1984) thus compete to see who can extract from nature and labor with as little return as possible. But why have socialists—surely not a group bound by conservative assumptions—tended to be blind to this issue? One reason might be the misleading colonial portrait we discussed earlier, in which indigenous societies in Africa and elsewhere were portrayed as trapped in negative feedback, remaining eternally fixed at barely above the subsistence level. Marx ([1939] 1973, 409–410), for example, explicitly stated that the unalienated labor of indigenous cultures, although admirable for its egalitarian relations, could not rise beyond *Natur-bedurftigkeit*. Only in extracting value and redistributing it in a top-down, alienated form from the state could we rise above "mere local developments of humanity" (409–410).

As we have seen, these contentions are factually incorrect. Bottom-up processes are not doomed to paltry existence, barely above the subsistence level; they can be profoundly

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productive and innovative. African traditions of generative justice—placing emphasis on the rights of those who generate value to enjoy its benefits in unalienated forms, control its conditions of production, and nurture its circulation—are a better model for the original indigenous traditions and for their new technological hybrids. The makerspace movement in Africa is not a silver bullet for all ills, but it is just one arena in which generative justice traditions can find new footholds in the path toward egalitarian and sustainable futures.

Note

1. See http://generativejustice.wikispaces.com.

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7
Making Mobiles African

Toluwalogo Odumosu

Mobile telephones and Africa have become a feel-good story of sweeping technological and social transformation and of the rapid acceptance of modernity by a continent long plagued by a surfeit of bad news. This is why, for example, African journalists Tolu Ogunlesi and Stephanie Busari could write a piece for CNN entitled "Seven Ways Mobile Phones Have Changed Lives in Africa."[1] Their narrative is simple: The mobile phone has transformed the continent. Education, health care, activism, disaster management, entertainment, banking: There seems to be no section of the African economy that has escaped the magic of the telephone. The article paints a picture of innovative solutions to specific challenges facing the continent, from countering the scourge of fake drugs in Ghana to election monitoring in Kenya using the Ushaidi platform. How did this happen, especially given the historical challenges other large technological infrastructures (such as electrical power) faced at adoption? This chapter argues that to understand the relative success of the mobile phone in Africa, we must understand the cultural and epistemic processes through which the African mobile emerges.

Mobiles and Place

What does it mean to examine how mobiles are being made African? Surely, mobile phone culture is a global phenomenon and a technology that has been adopted widely by various countries around the world, as evidenced by the high global demand for Apple's iPhone. However, upon careful inspection, unique dimensions of mobile telephony can be observed in individual nation-states and geospatial areas. Culture, national politics, geography, and available infrastructure all contribute to shaping mobile networks. Therefore, Ito, Matsuda, and Okabe (2005) can argue convincingly that the Japanese *keitai* is a different sociocultural object from the cellular phone in the United States (which Ito argues is defined by technical infrastructure) or the mobile in the United Kingdom (defined by the move away from the predetermined locations that landlines represented). Roughly translated, *keitai* means "something you carry with you." For Ito, the keitai is "not so much about a new technical

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capability or freedom of motion but about a snug and intimate technosocial tethering, a personal device supporting communications that are a constant, lightweight and mundane presence in everyday life" (Ito, Matsuda, and Okabe 2005, 1).

Ito thus makes the compelling argument that though mobile telephony systems in different nations may be technologically analogous, they possess different social histories and may occupy very different sociocultural niches. In a somewhat similar vein, the ethnography of Horst and Miller (2005, 2006) clearly describes the cultural construction of the cell phone in Jamaica. These studies of localized specificity in patterns of use and mobile culture are useful and important contributions to our understanding of the relationship between technology and society, and this chapter will attempt to do likewise in its examination of the state of mobile telephony in Nigeria and the broader implications of the Nigerian experience when we consider the continent of Africa.

Recent work on mobiles in Africa (de Bruijn, Nyamnjoh, and Brinkman 2009; Zegeye and Muponde 2012) have conceptualized the device in various ways to show how it is co-constituted with Africa. For example, de Bruijn, Nyamnjoh, and Brinkman (2009) in their comprehensive review show how various practices on the continent are generating new uses and innovations, such as in healing practices (van Beek 2009). Like many authors writing about science and technology from Africa (e.g., Mavhunga 2014), this chapter proceeds with an analysis from the viewpoint of Africans themselves (in this case, Nigerians) and seeks to explore their own practices and understandings of mobile technologies.

First, though, it is important to remember that the term *phone* (or in this case, *mobile telephony system*) is linguistic shorthand for institutions (mobile operators, regulatory bodies), technologies (GSM, CDMA), people, and practices (Sterne 2003). This heterogeneity requires that any robust examination of the telephony system *should not* be limited to the artifact that individual mobile users carry around and present when they are asked for their "phones." Rather, a thorough examination of mobile culture must also include an examination of regulatory practice, network design, and engineering culture, as well as the practices and behaviors of mobile users. In a quite literal sense, each phone is merely a node in an extensive sociocultural-material network, linked wirelessly to other mobile network devices, institutions, and people. Every *phone* (i.e., hardware that mobile users utilize in interacting with the mobile system) is engaged in a seamless, elegantly scripted, bidirectional, electromagnetic duet with other network nodes. In addition to these material elements, the heterogeneous mixture represented by *phone* includes the software and hardware engineers that specify and build the mobile telephony network, the multiplicity of mobile phone users, possibly a state-appointed regulator, billing and other financial arrangements, various mobile phone companies along with the expertise and human capital they contain, and, of course, the legal statutes that govern the behavior of the entire amalgam. In other words, any description of African mobiles must demonstrate how the various elements of this heterogeneous mixture are invested in the process.

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Constitutive Appropriation: An Analytical Perspective

The question of possible analytical frames in the study of mobile phone use culture is an important one, because analytical frames and conceptual modes do much to guide research questions and illuminate unique aspects of the case being investigated. Thus does Donner's (2007) choice of adaptive structuration theory emerge from his study of beeping practices, and the theory does much to illuminate the analysis that follows. Similarly, Horst and Miller (2006) use the concept of "communicative ecology" to great effect in their study of Jamaican cell phones. This chapter utilizes the concept of constitutive appropriation, building on the work of Eglash (2004), Jones and Twidale (2005), Bar, Pisani, and Weber (2007), and von Hippel (2005). A full treatment of constitutive appropriation has been undertaken elsewhere (Odumosu 2009); nevertheless a discussion of the salient points will be useful in analyzing the case under consideration in this chapter.

The concept of appropriation has been employed before by African authors writing about mobile phones (Zegeye and Muponde 2012). Eglash (2004) describes it as a focused examination of the "lay public as *producers* of technology and science" and against an understanding of the public as "merely passive recipients of technological products and scientific knowledge" (vii). For Eglash, appropriated technologies are critical because of "their potential contribution to sociopolitical resistance and social reconfiguration" (x).

Constitutive appropriation argues that consumption and production should be seen as analytical categories that are imposed on the messiness of the observed phenomena. They are both fully present simultaneously in the act of appropriation. The act of *using* a technological system entails *producing knowledge* about its possible and varied uses, constituting cultural practices around the artifact or system, the formation of community, and in some cases even the reconfiguration of the artifact or system itself—all activities subsumed in the term *consumption*. In a similar vein, the creation of a technological artifact involves production that always utilizes a resource, whether it be labor or goods and/or services, encompassing the design of the artifact, institutional arrangements that help define what the artifact is, the building of networks that give the artifact meaning, the creation of discourses that shape perceived acceptable and unacceptable uses, and sometimes imagining and creating the very publics that will be using said artifact.[2] In *The Grundrisse*, Marx argues similarly that "production is also immediately consumption. Twofold consumption, subjective and objective ... Consumption is also immediately production, just as in nature the consumption of the elements and chemical substances is the production of the plant" (Marks and Engel 1978, 228)

The point being made here is not that production and consumption are not useful concepts, but that each is contained in the other, and that when in mundane speech we refer to *production* or *consumption*, we are willfully highlighting one aspect of the phenomena and downplaying the other. This insight is important because of the traditional way in which "consumptive" and "productive" acts are viewed. Appropriation works by inverting our

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vision of the phenomena in question, highlighting the productive elements in acts that are usually viewed as consumptive in nature.

The framing of appropriation as the activity users undergo as they embed a technological system/artifact into their lives or social, economic, and political practices resonates with a media studies understanding of "domestication" (Silverstone and Hirsch 1992). Within their theory of the "moral economy of the household," Silverstone and Hirsch identify four distinct phases in the dynamics of this moral economy, of which appropriation is the first, followed by objectification, incorporation, and conversion. For Silverstone and Hirsch, *appropriation* is the point at which an object leaves the world of commodities and is taken possession of by individuals or households and owned. As noted by Oudshoorn and Pinch in the introduction to their edited volume, media and cultural studies have "recognized the importance of studying users from the very beginning. Whereas historians and sociologists of technology have chosen technology as their major topic of analysis ... cultural and media studies have focused primarily on users and consumers. Their central thesis is that technologies must be culturally appropriated to become functional" (Oudshoorn and Pinch 2003, 12).

In summary, a few points emerge as pertinent to a theory of appropriation—a theory that, for the purpose of differentiation, I assign the label *constitutive appropriation* (I have appended the adjective *constitutive* as a reminder of the productive nature of the act of appropriation):

1. Constitutive appropriation can be described as the process whereby one or more users makes a technological artifact or system theirs, integrating it into their sociocultural world and in the process transforming said artifact or system to serve the user's ends (Eglash 2004; Oudshoorn and Pinch 2003).
2. Constitutive appropriation by definition, then, is not necessarily circumscribed to studies of the marginal. It can be used in a more general sense (von Hippel 2005; Jones and Twidale 2005; Bar, Pisani, and Weber 2007).
3. Consumption and production should not be viewed as opposite ends of a continuum; there is much to be gained by seeing them as operating simultaneously (von Hippel 2005; Marx and Engels 1978).
4. Constitutive appropriation is seen clearly in the mundane processes of integrating systems and artifacts into the lived experiences of individuals and *communities*. Any description of this process should attend to possible reconfigurations of social life (Silverstone and Hirsch 1992).

With this analysis in place we can proceed with an examination of the process of making mobiles African. I offer here two "selfies"[3](by which I mean captured moments of self-reflection) of this process as it took place in Nigeria during fieldwork conducted in Lagos and in the Nigerian capital of Abuja from 2006 to 2008.

The first selfie, following the work of Nkomo and Khumalo (2012) on the linguistic impact of mobiles on Zimbabwe, is a discussion of the linguistic and epistemic difference between landlines and mobile phones in Nigeria. The second is an exploration of how Nigerian mobile

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network engineers came up with innovative solutions to the unique challenges of building mobile networks in Nigeria and the reverberations that had on the design of global mobile network systems.

Is That a Landline in Your Pocket?

Her name was Jumoke. I met her a few weeks before I arrived in Lagos to start fieldwork. She was the first to introduce me to the dissonance between conceptual maps of mobile phones and land-phones, as opposed to the general meanings attached to those terms in the United States. I was invited into her kitchen; I found her seated at the kitchen table with three devices that all looked like phones and, at least to me, were inherently mobile—that is, lacking wires and possessing a small form factor. She was busy working on all three phones. Two of the devices had their batteries out, and the last one was being used to place a call. While carrying on a conversation on one mobile phone, she motioned for me to seat and wait. As I complied, she proceeded to attend to multiple tasks. Talking on one of the phones, she simultaneously swapped small electronic cards in the other two. When she was finally done talking, I asked her what she had been doing with the other two phones and why she had three phones. She patiently explained that she was moving the SIM card from one of her mobile phones to the other, while speaking to her fiancé on her "landline." I pointed out that all three phones were capable of being moved from one place to the other; indeed, a stranger examining all three devices would probably not detect any major differences in their shapes, forms, or use possibilities. Such a stranger would most probably therefore conclude that all three devices would fulfill any reasonable criteria to qualify as mobile phones. Jumoke agreed with this observation, then patiently explained to me the differences among the three phones. Two of them, she said, were mobile phones—GSM phones. The last was a "landline"—a CDMA line. The reason she was swapping SIM cards was that one of her mobile phones' batteries had lost its charge and she wanted to use the "credit" on the other "line" to place a call.

Speaking the Language

In the course of my field work, I became intimately familiar with terms like *SIM card*, *GSM*, *CDMA*, *credit*, *landline*, and *mobile line*. They are terms that most Nigerians have come to understand intuitively. They require no explanation in Lagos, or elsewhere in Nigeria. These terms have become part of the lexicon of everyday speech on the streets of Lagos, perhaps best described by Bourdieu's notion of *doxa*, in which natural and social worlds appear to be self-evident (Bourdieu 1977, 164). To anyone immersed in the specific mobile phone culture of Lagos, knowledge of these terms and their meanings has become innate—a testament to the pervasiveness and widespread adoption of telecommunication technologies. For example, the argument can be made that *credit* was a commonly used word in Lagosian parlance before 2001. Since the advent of mobiles, though, the term "credit" now has an added meaning.

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A point that quickly becomes apparent to the stranger visiting Lagos is that people living there perceive a marked difference between GSM/mobile and CDMA/landline and use the terms interchangeably in daily mundane conversation; that is, GSM is analogous with mobile and CDMA is at times analogous with landline. Here, the term *GSM* or *mobile* does not imply mobility, but rather a type of small, portable phone that possess an eleven-digit number and is capable of functioning anywhere in Nigeria. On the other hand, *CDMA* or *landline* implies a small, portable phone that has a seven-digit number and is usually only functional in a certain geographic region (for example, the state of Lagos). The argument could therefore be made that in Lagos, Nigeria, the term *mobile phone* does not even mean the same thing as it does elsewhere in the world. In other places, the *mobile* in *mobile phone* usually refers to the mobility of the communication device (phone), which is historically understood in contrast to the immobility of the preexisting, widely available copper telephony infrastructure. In Lagos, the historical nonexistence of such a nationwide copper-based telephone network has had a different effect, and mobility (defined here as a lack of wires) per se is not seen as a salient feature; indeed, in most cases it is assumed to be constitutive of telephony technology and not particularly interesting. The historical context in Nigeria has thus led to the state of affairs in which the term *mobile* more often than not references a particular technological configuration and not necessarily the mobility or immobility of a particular device.

This difference in meaning attached to *mobile* is particularly interesting, especially in the light of particular research trajectories of scholars working predominantly in countries with a history of widely available copper lines, where a significant portion of the research design has historically focused on the "mobility" of these new communication devices and the subsequent implications of this new mobility (Katz and Aakhus 2002; Katz 2006). Mobility would probably not be as interesting in the same way to a researcher working from a country like Nigeria, because most Nigerians view the mobility of communication technologies not as a new feature that may possibly reconfigure social life, opening up new ways of being, but as an integral part of any contemporary telecommunication infrastructure. This point also calls into question the inherent problematic of the discourse of "technological leapfrogging," in which countries like Nigeria are celebrated as having "skipped" the copper phase and moved to an all-wireless state of affairs. This way of framing presupposes the centrality of the technological history of a number of wealthy countries and evaluates developments elsewhere on that basis. It is only in such an analysis that a nation can leapfrog copper and move straight to wireless. A much more nuanced picture emerges when technological choices and sensibilities are evaluated within the specific histories of the countries within which they emerge.

During field work, I regularly met people who carried multiple phones around with them. A typical response to my questioning of this behavior was that one phone was a landline and the other a mobile phone. Nigerian users thus appear to use different terms to describe different aspects of the devices they carry around with them. Closer attention to these terms reveals a sophisticated complexity and grasp of not only the materiality of the technologies

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in use, but also a fluidity in the normative meanings attached to concepts like landline and mobile phone, GSM and CDMA. It therefore is useful to probe these concepts and their areas of overlap and divergence.

Mobiles, Language, and Technological Understanding

Upon initial inspection, it appears that there are two classificatory systems at work here. One addresses the underlying technology that a device utilizes—GSM or CDMA—and the other is more concerned with the use of the device, mobile (portable) or landline (fixed). Although these classificatory schemes overlap, it would be wrong to infer that they are synonymous. What does it mean to identify a device as a mobile phone to a Nigerian user? Why did some of the people I spoke with respond to the question, "Is that your landline?" with, "No, it is my GSM." As always, meaning is contingent and contextual.

In Nigeria's "communicative ecology" (Slater and Tacchi 2004), users appear to categorize mobile operators according to the technologies they deploy in their networks. Currently, the marketplace is dominated by two distinctive technologies, GSM and CDMA. This bifurcation is transparent to Nigerian users in obvious ways.

First, GSM networks have different numbering schemas from CDMA networks. GSM numbers in Nigeria are eleven digits long. CDMA lines have traditionally been only seven digits long, along with a state code that identifies the calling area in which the number resides. In contrast, landline numbers and cell phone numbers in the United States, for example, are indistinguishable based on the length of the number, and it is impossible to determine the underlying technologies based on an evaluation of mobile phone numbers.

Also in Nigeria, the user-side hardware (the actual phone) is different under each system. The GSM (mobile) phones are usually more sophisticated, and there is a larger selection available than there is in the CDMA system. From the user's perspective, the most visible differentiator between CDMA and GSM (as of 2006) appeared to be the SIM card. The phones themselves are interestingly more transient; most of the people I spoke with had previously owned more than one phone and were always on the lookout for an opportunity to upgrade their phones. When asked, "How can you tell landlines from mobile phones if they are both easily carried around?" the standard response was, "Mobile phones have SIM cards, landlines do not."

In other parts of the world, when asked about the differences between landlines and mobile phones most people would probably respond that landlines are connected to a local phone company through physical wires, whereas mobile phones are wireless. Although the reality of this insight is slowly changing, driven by services from nontraditional VOIP companies, one suspects that the majority of telephony users in nations with extensive copper wire infrastructure still hold this view. In addition, most VOIP users still connect traditional phone sets to their "landlines" in their homes, and thus *home phone* is usually synonymous with *landline*. In the Nigerian case, in which a fixed copper infrastructure was only available

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to few and has retrograded to the point of near obsolescence, a different understanding of what a landline is has emerged. Here, the idea of a landline is closely correlated with lower tariffs, eight-digit numbers, CDMA technology, and phones that are usually light on features compared to their GSM counterparts. Landlines can be mobile, or they can be fixed. They can be fixtures in homes or can possess the same level of mobility as "mobile phones."

Thus, in Nigeria, although GSM and CDMA are seen as competing technological standards (developed in Europe and the United States, respectively), they are also identifiers of competing wireless network operators. Similarly, the concepts of mobile and landline do not refer to the mobility or immobility of devices or even to the presence or absence of a copper infrastructure, but rather to many different things: tariff structure, underlying technological standard, numbering scheme, and regional versus national service coverage. This is not to suggest that there is market parity between the two systems; GSM dominates the market and in many ways is the predominant standard, shaping user expectations of CDMA networks.

Configuring a "Nigerian" Mobile Network

The second selfie is a tale of engineering culture and presents a situated perspective that is unique to the Nigerian experience. This is a tale that resonates with me, inhabiting as I do the hybrid identity of being an engineer and STS scholar. It requires seeing the mobile system from a privileged viewpoint—that of a core network engineer. It is important to qualify the kind of engineer, because there are different types of engineering work involved in making any mobile system function. The engineers we are concerned with here are responsible for maintaining the core network: They specify, build, and optimize all the elements in the switching subsystem (also known as the *core network*). These elements include mobile switching centers (MSCs), base station controllers (BSCs), home and visitor location registers (HLRs and VLRs), and other specialized network equipment. Figure 7.1 presents a simplified diagram of a typical mobile telephone system network topology, with the relevant core network elements circled.

The core network is so named because it is the heart of the mobile telephony system. The elements outside the circle are the base transceiver stations (BTSs) and individual mobile terminals—that is, phones (users are not shown on diagram because they are not typically indicated in diagrams of this sort that engineers utilize). Individual mobile phones communicate with the BTS, which is the interface between mobile phones and the network. The BTS is primarily a collection of transmitters and receivers that communicate with individual phones. BTSs have limited local intelligence and are directed and controlled by the BSC. BSCs monitor and control several BTSs and are in turn monitored and controlled by an MSC, which is the primary controller and processing hub of the network. If a wireless network can be described as having a heart or a brain, the MSC would fulfill both functions. The other elements in the diagram are ancillary and work as supportive agents for the MSC. The HLR is a database system of sorts that stores information about individual subscriber identities, and

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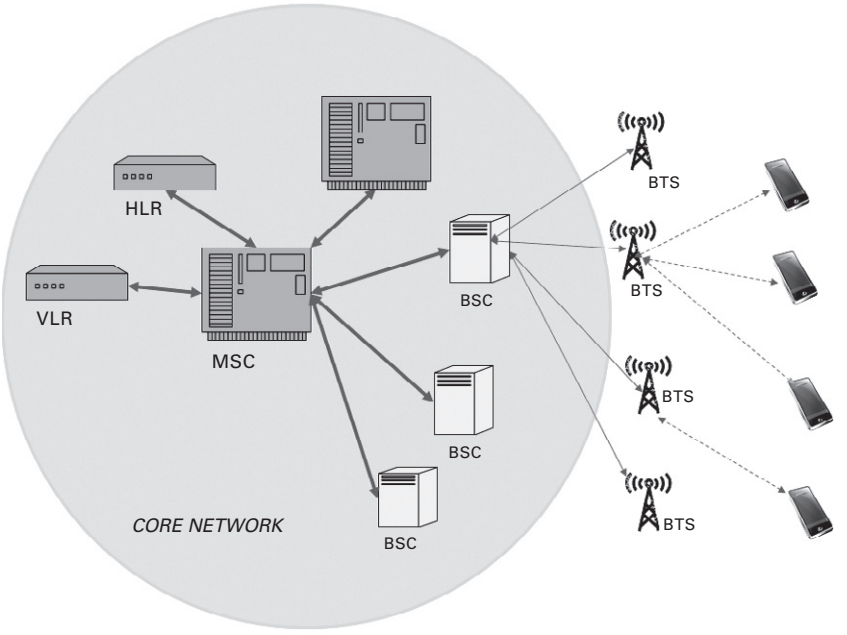

Figure 7.1
Typical network topology, showing elements in the core network.

the VLR is a similar system that caters to visitors to the network (e.g., roaming "guests" from other countries). This simplified diagram leaves out a number of elements because they are not necessary for telling the tale.

In order to appreciate the story to come, it is important to know a little about how a mobile telephony network handles calls. Telephone calls on GSM mobile networks are complicated things. Each call requires a number of operations and generates multiple control messages between the phone and the rest of the network. When a mobile user dials a number, the network sends information back and forth in a process referred to as the *call setup procedure*, which prepares and makes available a *voice channel* that will carry the conversation between both parties of the call. This *setting up* process involves a number of database queries to determine the last known position of the party being dialed in order to get the phone on the other end to ring. All this activity on the network is called *signaling traffic*—differentiated from *voice traffic*, which is traffic that is billable and thus earns money for the mobile operator. Signaling traffic is a continuous phenomenon, occurring in the background; as long as a mobile phone is switched on, it is required to constantly update the network about its geographical location and status. However, signaling traffic intensifies when a call is in the process of being placed.

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In conversations with radio and network engineers at MTN (the largest network operator in Nigeria), I learned that when it came to configuring the mobile network in Nigeria, the traditional rules that were invoked as standard and conventional failed miserably. Following generally accepted rules and practices, MTN engineers designed and configured their network to handle the specified number of users on their network, taking into account the geography of the coverage area, frequency selection, size of each cell, and other important variables. However, the network that resulted from the outcome of this design process quickly ran into problems as crucial sections of the core network became saturated and acted as bottlenecks to the flow of traffic, bringing the network to its knees. These problems elicited complaints from users all over the country; in response, the Nigerian Communication Commission (NCC) put pressure on MTN and other operators. In response, MTN stopped accepting new subscribers for a time while they tried to figure out the root cause of the problems.

As I reconstructed their efforts over the course of multiple interviews, a picture of what they were up against emerged. It turns out that mobile users in Nigeria behave differently from mobile users elsewhere, and it was this different behavior that made all the old rules of *dimensioning* (an engineering term that refers to the process of generating specifications based on particular constraints) the network irrelevant. As the engineers responsible for dimensioning the network quickly discovered, the standard rules did not apply. Their solution was *overdimensioning* the network (i.e., going beyond the standard recommended values). This was achieved by using more BSCs, and fewer BTSs per BSC, increasing the number of MSCs, and upgrading the data link communication channels between core network elements (represented in figure 7.1 by solid lines; the radio connections are represented by dotted lines). It was only after these substantial and expensive changes that the network was sufficiently robust and capable of handling the *kind* of traffic that Nigerian users generated. In the words of a top executive at MTN who managed the network directly, "What is really strange in Nigeria is that we have a very high busy hour call attempt ... whereas in a country like South Africa and a lot of other developed nations you see between 1 and 1.5 busy hour call attempts, the average here is about 3.6 or 3.9." The CTO added: "In Nigeria what you find is that subscribers have quite short Mean Hold Times. 19 seconds for outgoing calls and 32 seconds for incoming calls" (MTN executive, personal communication, July 3, 2008).

These two indices—mean holding time (MHT) and busy hour call attempts (BHCA)—are ways of describing mobile phone user behavior. They also have a tremendous impact (at least in Nigeria) on the way networks are designed. The MHT index on the MTN network was woefully small and measured in seconds, whereas according to the CTO, European indices are usually measured in minutes. MHT reflects the average amount of time users spend on a call. Nigerian MTN users stay on the phone for an average of roughly nineteen seconds per call. In essence, they spend a short time on the phone speaking if they initiate the call and roughly one and a half times as long if they receive the call. This discrepancy between time spent when receiving a call and time spent when making a call may be explained in some measure by the fact that the policy of mobile phone billing in Nigeria is the same as in

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Europe (the calling party pays); the effect of this is that the party placing the call shoulders the entire cost and the party on the receiving end pays nothing.

BHCA is a teletraffic measure that represents the number of calls attempted at the busiest hour of the day by all users. In experiential terms, a BHCA of 3.9 means that Nigerian subscribers at the busiest hour of the day, when confronted with a busy signal, will retry four more times before giving up. "Developed nation" (in the words of the MTN CTO) users, on the other hand, usually try just one more time and then give up upon receiving a busy signal. By interpreting both indices, a picture emerges of the average user during peak periods.[4] In addition, the high prevalence of *flashing* (cf. Donner 2007)—a practice that uses missed calls to communicate—also qualifies average Nigerian users. The average Nigerian mobile phone user only stays on the phone for nineteen seconds once connected. If the line is busy, said user tries immediately to make another call and, if unsuccessful, keeps on trying at least four more times. In addition, if said user is able to make a connection, they sometimes drop the call almost immediately and use the opportunity to "flash." As mentioned previously, each time a call is initiated the network needs to locate the mobile phone of the receiving party (which it does by querying its databases) and then actively select and devote voice channel resources to the call. All this requires substantial processing by the MSC and utilizes valuable bandwidth as messages travel back and forth among the various network elements in their effort to accomplish this process, which in engineering speak is referred to as *call setup*. These processes utilize the processing capacities of the MSC, HLRs, and VLRs, *even if the call does not go through* (i.e., is unsuccessful for whatever reason). Taking into account the high BHCA and the low MHT, it is easy to see how the network can quickly become saturated, as subscribers who are unable to get through have precious limited resources allocated to them. They keep on trying, tying up further network resources, only to get through and spend a short time on the phone before making another call.

The result of attempting traditional dimensioning methodology was that though the network could *theoretically* (here, the basis of the theory was the behavior of a well-known quantity, the average South African or European user) handle all the traffic, the processing capacity limit was being reached quickly, and very few calls (if any) were being successfully routed. MTN had to go back to the drawing board and redesign the network (based on the real Nigerian user). This resulted in the network being over-dimensioned with respect to the old standard. In effect, this meant using more MSCs and BSCs and implementing high-speed links between them.

It is important to point out that overdimensioning the mobile network was not driven by the need to handle larger amounts of mobile traffic than was expected, but rather by the need to handle a *different kind* of traffic. In engineering vernacular, the *traffic profile* of Nigerian users required a fundamentally different kind of network. As MTN built out (produced) its network, what was being used up (consumed)? This question naturally leads to an examination of the relationship between MTN and its suppliers. As a large transnational corporation with substantial buying power, MTN operates in a relatively small market (there are not

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that many mobile operators in the world) and as such enjoys a closer coupling with suppliers and has much greater input into the design cycle of the businesses from which it purchases its equipment. It was therefore inevitable that the challenges of building GSM networks in places like Nigeria would be brought to the attention of MTN's suppliers—in this case, the Swedish global telecommunication giant Ericsson. Observations about the strange behavior of Nigerian users were communicated to Ericsson by MTN. The challenge was that Ericsson's designs for mobile network devices were predicated on the existence of a specific kind of user (e.g., users in South Africa), and the implied traffic profile guided design decisions relating to network processing capacity. Because Nigerians used their mobile phones differently, it quickly became apparent that the standard processing capacities were inadequate to deal with the traffic profile, hence the need to overdimension: buying more devices than usual in order to provide the network with greater processing capabilities.

Ericsson and other core network equipment manufacturers have since developed new designs for their network devices (based on blade server architecture) that allow their end users (the mobile operators) to upgrade specific portions of the hardware.[5] These new designs allow for selective upgrades to the processing capabilities of mobile networks. As an example of constitutive appropriation, this example highlights the importance of paying attention to the dualism of production and consumption. It is true that the MTN engineers were in many respects the designers of the mobile network. However, it is also true that the Ericsson representatives I spoke with in London saw and spoke of the MTN engineers as *their* users. The MTN network engineers, when faced with different mobile user behavior (in the form of unique traffic profiles, short mean call times, high BHCA, and flashing), adapted by deploying core network elements in new configurations, ignoring standard rules of network dimensioning. Even more interestingly, by problematizing particular aspects of the architecture of the MSC (i.e., processing capacity vs. switching capacity) and communicating that information to their suppliers, the network engineers at MTN may have catalyzed the development of new switch architectures that led to scalability of MSC processing power—affecting the design of future individual mobile network components (MSCs and BSCs).

How should we make sense of these two selfies, and what insights do they provide in understanding how the African mobile is being made?

Conclusion

One important point is that as Nigerian engineers and system designers encountered the behavior of actual Nigerian users, they determined that a fully functional *Nigerian* network has to take into account real users and their particular use practices. The result of their constitutive appropriation was a mobile network that was materially, topologically, and instrumentally dissimilar to networks of similar size and membership elsewhere in the world. The case studies presented in this chapter also reverse the traditional role of engineering system designers solely as productive actors.

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In addition, the cases point to the innovative paths that mobile network technology proceeds upon, on which new challenges and practices inspire new language, new understandings, designs, and innovative solutions (overdimensioning) that can then be folded into the upstream design process in tangible and substantial ways—such as new blade server designs! It is clear that following the actors and artifacts (at least in this example) requires us to rethink our classical assumptions about the categories of *users* and *producers*. In this case, they are not ontologically reified; rather, these categories *describe functional relationships*. In other words, the Nigerian engineers and system designers here are simultaneously users *and* producers.

Returning our attention to the question of the "African mobile," what does it mean to say that mobiles have been made African? The Nigerian case clearly illustrates that local context can affect the shape and outline of national mobile telephony design, yet it is also true that there are similar factors in various African nations that can materially contribute to the design of mobile telephony networks. For example, the challenge of delivering electrical power to various base stations is a common challenge faced across most of the continent. In some areas, the problem lies in a troublesome electrical grid; in other areas, there is no grid. These common challenges have exerted an influence over how mobile networks in Africa are designed and run. In particular, lower-power, high-efficiency base stations that are resistant to wide voltage variability have become a design criterion. Although it is perhaps too early to conclude that the African mobile, like the Japanese *keitai*, is a singular sociocultural construct, it is clear that the social, political, and infrastructural peculiarities of the continent are shaping the design and development of mobile telephone networks there. There is no singular African mobile, but we can expect a family resemblance among the various national instantiations. Furthermore, the emergence of this African mobile owes much to the innovative solutions and creative problem solving of thousands of African mobile network engineers. After all, the essence of engineering is creative problem solving.

This chapter contains two examples of Nigerians and Nigerian society engaging in acts of appropriation, and thus we may fruitfully inquire: Does this happen because there is something unique about the Nigerian situation? For example, the overdimensioning of the mobile system by network engineers is indicative of the type of appropriation of traditional practice that Dosunmu (2005) points out is occurring in Wole Soyinka's play *Death and the King's Horseman*.

Although it is difficult to delineate direct causal links, what is undeniable is that Nigeria has a history of being innovative. From the post–World War II Onitsha Market School of novelists,[6] responsible for the boom in indigenous pop culture novels during the 1980s, to "419 scams" (Odumosu and Eglash 2010) that utilize emails and faxes to prey on people for money, either through sympathy or greed, Nigerians seem to have a knack for embracing technologies and making them their own. We can also add to this list the exponential growth of the Nigerian home movie industry—Nollywood (Marston, Woodward, and Jones 2007)—which began by utilizing video recording equipment designed for making movies at home to

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tell traditional and contemporary stories through the popular VCD format. This practice has clear historical roots in the traditional Yoruba culture of drama and dance (Dosunmu 2005). Perhaps the Nigerian cultural history of innovating has some role to play in the dynamism of the examples discussed here. It is important to note that all of these practices have a few things in common, not the least of which is the political history of colonization and the abject failure of the mechanisms of the state. The fact that the bustle and excitement of Nollywood, the 419 scams, and the ingenuity of overdimensioning the mobile network all emerge from the same history is instructive.

Notes

1. See http://www.cnn.com/2012/09/13/world/africa/mobile-phones-change-africa/.

2. Callon's (1987) study of the electric vehicle (VEL) in France illustrates the point that engineers involved in the design did not just design the vehicle, but also imagined the society in which it was to be used, including the role of users and their anticipated behavior.

3. My use of the term *selfie* is deliberate. To take a selfie is to use a mobile phone as a tool of self-inspection and representation—that is, to turn the gaze of the camera back on one's self. As an African, an STS scholar, and an engineer, this term is particularly useful for me in this text.

4. Of course, said "average user" is a fiction generated by these numbers. In reality, Nigerian citizens vary widely in their use of mobile technology, with some users spending much longer on calls and others spending shorter amounts of time on calls. For more on the construction of both users and nonusers, see Wyatt 2003.

5. I tried in vain to establish direct causal links between the concerns of organizations like MTN about the need to overdimension their networks and the new initiatives from Ericsson to introduce new product architecture that allows for specific upgrades as required. I visited Ericsson offices in London and Lagos, and in the course of conversations with various engineers and project managers I was able to establish that the design cycle directly utilized user feedback (here, the users are the mobile operators), but there were other considerations that led to these substantial changes, including advances in computer hardware technology. In other words, Ericsson engineers were hesitant to fully attribute their new design decisions to the kinds of user feedback described here. They did, however, concede that "emerging markets" like those in Africa were crucial to their ongoing success, and as such the needs of such markets were influential in the decision-making process.

6. Cypian Ekwensi, probably the most prolific Nigerian author of all time, is associated with this school.

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8
Innovation for Development: Africa

Garrick E. Louis, Neda Nazemi, and Scott Remer

Introduction

This chapter is about Africa, but much of the data is taken from reports that list sub-Saharan Africa (SSA) as an entity distinct from North Africa (NA) and the Middle East and North Africa (MENA). We do not agree with these distinctions but use them because of the data. Furthermore, Africa is a continent of fifty-four countries, each with its own individual profile of development issues and innovation priorities. Therefore, this discussion of Africa as a continent is subject to all the flaws of aggregation and does not completely represent the situation in any specific country. Finally, we acknowledge that metrics for and representations of human development used by the international community are embedded with Western values about development that may be different from African beliefs about development. We note these shortcomings to the reader even as we use the metrics and representations to argue for strategic African innovation for human development in Africa.

In this chapter, we define *innovation* as the creation or enhancement of artifacts to improve the human condition. These artifacts may be tangible, such as devices and services, or they may be intangible, such as philosophical concepts (e.g., democracy, ethics, equity) or processes (e.g., an application for a building permit). We can think of three general categories of innovation: incidental, institutional, and strategic. *Incidental innovation* is unintentional discovery or invention by an individual or group—for example, Velcro (Suddath 2010). *Institutional innovation* arises out of organized research sponsored and/or conducted by private companies, academic institutions, and the government. This category may be subdivided into basic and applied research. *Strategic innovation* consists of planned, systemic efforts coordinated by the government and aimed at achieving well-defined national goals, such as human and economic development. It can be a leveraging complement to a nation's incidental and institutional innovation.

Africa has a history of all three forms of innovation that spans millennia before colonialism. An example of institutional innovation is the making of high-grade carbon steel by the Haya people of Tanzania as far back as two thousand years ago. The steel was produced in

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kilns that reached temperatures of 1800°C, which was 200 to 400°C hotter than kiln temperatures in Europe before the industrial era (Blatch 2013; Lienhard 1988–1997a, 2004; Shore 1983). Examples of strategic innovation in precolonial Africa can be found in the governance in its ancient city-states, such as Great Zimbabwe, the city-state that featured a 250-meter long, fifteen-thousand-ton, curved granite wall (Blatch 2013; Lienhard 1988–1997b, 2004; Asante and Asante 1983). There are many other examples—including in the incidental innovation realm—in astronomy, mathematics, medicine, and even hunting (van Sertima 1983; Mavhunga 2014). These examples underscore the point that Africa has a long and broad history of innovation. However, this history—and continued African innovation—has either been appropriated without acknowledgment by others from outside Africa, been suppressed as a threat to established power and ways of thinking about Africa, or remains unrecognized and underdeveloped by a system of scholarship and enterprise that largely ignores innovation *from* Africa (Rodney 1972; Cooper 1994). This denial includes both indigenous innovation that originates in Africa and innovative African adaptations of existing artifacts that were produced outside Africa or by non-Africans.

Africa faces significant human, social, and economic development challenges today, as described further on in this chapter. Africa needs innovation of all forms to overcome these challenges. This innovation is most likely to be effective and sustained if it builds upon and leverages domestic capacity within Africa.; it must also emphasize strategic innovation focused on the goal of African development. This chapter makes the case for strategic innovation for African development in Africa and by Africans (Watkins and Ehst 2008) through five main points:

1. Africa has a pressing need for essential human services.
2. These services are necessary stepping-stones on the path to development.
3. Countries have to build domestic capacity to provide these services in order to sustain their drive to higher levels of development.
4. Capacity building, broadly defined, is an effective framework for innovation for development (IfD).
5. Official development aid (ODA) must prioritize capacity building that fosters African innovation for development.

Africa Has a Pressing Need for Essential Human Services

By many commonly reported indicators of human development, Africa compares unfavorably to other regions of the world. Table 8.1 illustrates this point for selected indicators from the 2014 Millennium Development Goal (MDG) Report (UN 2014).

These indicators are highly selective, are embedded with the values of the agencies that compile them, and do not capture the multiple dimensions of well-being that constitute development. However, because they are broadly and commonly used, their familiarity can

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Table 8.1
MDG indicators* by UN World Regions**

Indicator	SSA	NA	LAC	SA	OC	SEA	EA	CCA	WA
1a. Proportion of people living on less than $1.25 a day, 2010 (%)	48	1	6	30	n/a	14	12	4	4
1b. Proportion of undernourished people, 2011–2013 (%)	25	< 5	8	17	12	11	11	7	10
2. Adjusted net enrollment rate for primary education, 2012 (%)	78	99	94	94	89	94	97	95	93
3. Employees in nonagricultural wage employment who are women, 2012 (%)	33	19	44	20	38	39	42	44	20
4. Under-five mortality rate, 2012 (deaths per 1,000 live births)	98	22	19	58	55	30	14	36	25
5. Maternal mortality ratio, 2013 (maternal deaths per 100,000 live births, women aged 15–49)	510	69	n/a	190	190	140	33	39	74
6. New HIV infections per 100 people per year (2012 estimate)	0.16–1.02	0.01	0.03–0.05	0.02	0.03	0.03	0.01	0.02	0.01
7. Proportion of population using an improved drinkingwater source, 2012 (%)	64	92	94	91	56	89	92	86	91
8. External debt service payments as a proportion of export revenues, 2012 (%)	3.3	4.4	6.6	3.0	1.8	2.5	0.4	1.1	6.6

*These indicators are for relative comparison only. They may not reflect local value systems.
**SSA—sub-Saharan Africa; NA—North Africa; LAC—Latin America and the Caribbean; SA—South Asia; OC—Oceania; SEA—Southeast Asia; EA—East Asia; CCA—Caucasus and Central Asia; WA—West Asia.
Source: UN 2014.

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provide a starting point for this discussion. By the indicators of poverty and hunger (Goal 1), universal primary education (Goal 2), child mortality (Goal 4), maternal health (Goal 5), infectious diseases (Goal 6), and access to an improved water source (Goal 7), SSA ranks last when compared to other UN world regions. On the indicator for gender equity and empowerment of women (Goal 3), SSA ranks sixth of the nine UN world regions, and it ranks fourth of nine on the indicator for building global partnerships for development (Goal 8).

What does this imply for a strategy for African development? What should the priorities for innovation be to foster such development? To answer these questions, it is necessary to first define some key terms: *poverty*, *development*, and *innovation*.

Essential Human Services Are Necessary Steps toward Development

We define *poverty* as the incapacity to achieve one's human potential within the era in which one lives. Here, *human potential* refers to the full contribution that an individual is capable of making to society. Maslow's self-actualization in a hierarchy of needs provides a convenient, though more individualistic, illustration of this concept, as represented in figure 8.1 (Maslow 1943). The World Bank and the United Nations have similar definitions: *poverty* is generally defined in relation to "whether households or individuals have enough resources or abilities today to meet their needs" (Coudouel, Hentschel, and Wodon 2002; Narayan et al. 2000; Smelser 2001). We propose two categories of human needs: *primary* or basic needs, and *secondary* needs. In social groups, these needs are provided by means of infrastructure in the form of essential human services (EHS). Table 8.2 summarizes primary needs and selected secondary human services; these needs coincide with the physiological and safety needs of Maslow.

Figure 8.1 suggests a set of steps to go from the physiological or basic human needs to the level of self-actualization, achieving one's human potential. Indeed, one definition of *development* is the process of achieving one's human potential.[1] Here, "one" may be an individual or a group within a larger social context (Soubbotina and Sheram 2000).

In order to achieve one's human potential, one needs the capabilities or skills and the opportunities and choices to do so (Baroudi 2004). Thus, *human development* is the extension of human capabilities and expansion of the choices available in all aspects of personal and social endeavor for all individuals and groups in a society. *Innovation* as defined earlier is the creation or enhancement of artifacts to improve the human condition (Greenhalgh and Rogers 2010). Thus, *innovation for development* is the creation or enhancement of artifacts that allow people to achieve their human potential (Lopez-Claros and Mata 2010).

In its 1990 Human Development Report, the UNDP stated: "People are the real wealth of a nation. The basic objective of development is to create an enabling environment for people to live long, healthy, and creative lives" (UN 1990, 9)—that is, achieve their human potential. If the role of government is to secure and sustain the wellbeing of its people, then governments,

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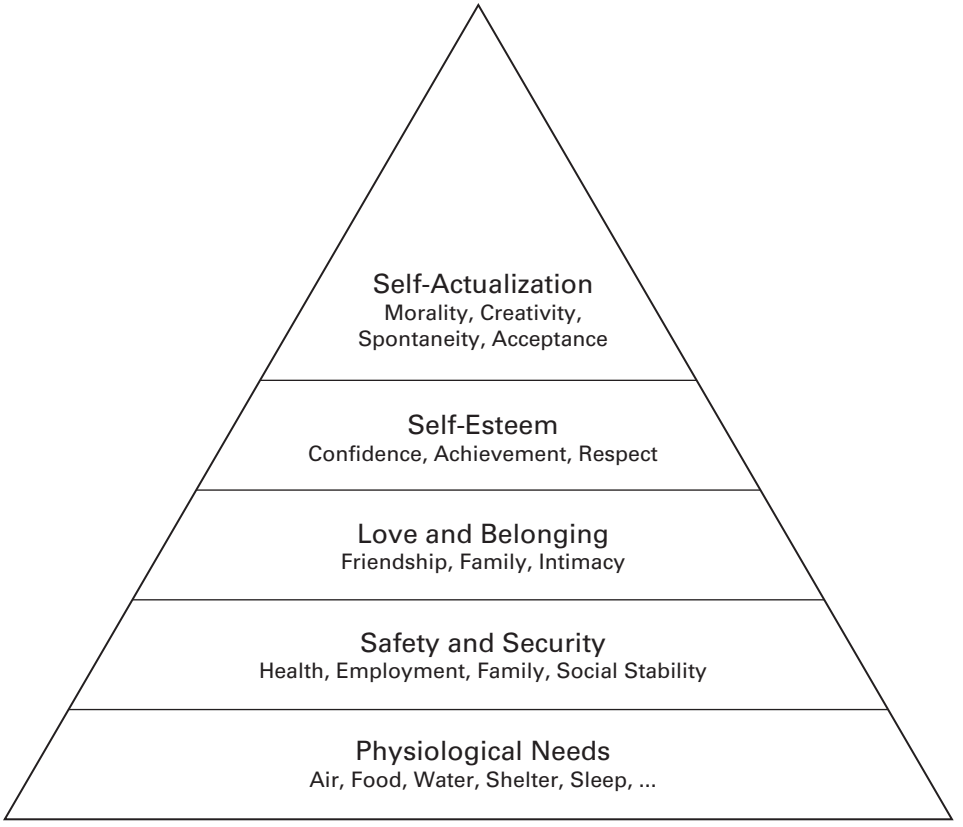

Figure 8.1
Maslow's hierarchy of needs.
Source: Adapted from http://communicationtheory.org/maslow's-hierarchy-of-needs/.

Table 8.2
Primary needs and selected secondary human services

Primary needs	Secondary services
Water	Education
Sanitation	Healthcare
Shelter (including clothing)	Employment/commerce
Air (indoor)	Electricity
Household energy (cooking, heat, light)	Communications
Food	Transportation
Personal security	Governance/social stability

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including those in Africa, are engaged in creating the means for people to achieve their human potential. Thus, governments are engaged in innovation for development.

This chapter posits a two-part strategy for national development. The first part prioritizes national investments in the order of human needs. Thus, the highest priority would be given to the basic human needs at the bottom of the pyramid in figure 8.1 and would be apportioned accordingly as people move up the pyramid. This is not a linear process: Certainly, all of a nation's needs have to be met to some degree simultaneously. Thus, water and sanitation must be provided at the same time as healthcare, education, and national security. However, in order to put its people on the path to self-actualization, a nation as a people must acquire the capability to provide for their most basic human needs, then move onto the capability for secondary and other higher-order needs. Figure 8.2 illustrates this relationship among basic needs, capabilities, and levels of human development.[2] Levels of human development reflect Maslow's illustrative hierarchies on the left side of the pyramid. Capabilities to meet those needs begin with the awareness of basic human needs and the social cooperation to address those needs through the combination of natural resources and energy, as well as economic/financial, technical, human resource, and institutional capacity. Thus, capacity factors represent the capability necessary for self-determined, sustained human development along the lines of Sen's "capability as choice" view (Sen 1985, 1999). Figure 8.2 represents social cooperation to address mutual needs as the most fundamental level of capability and

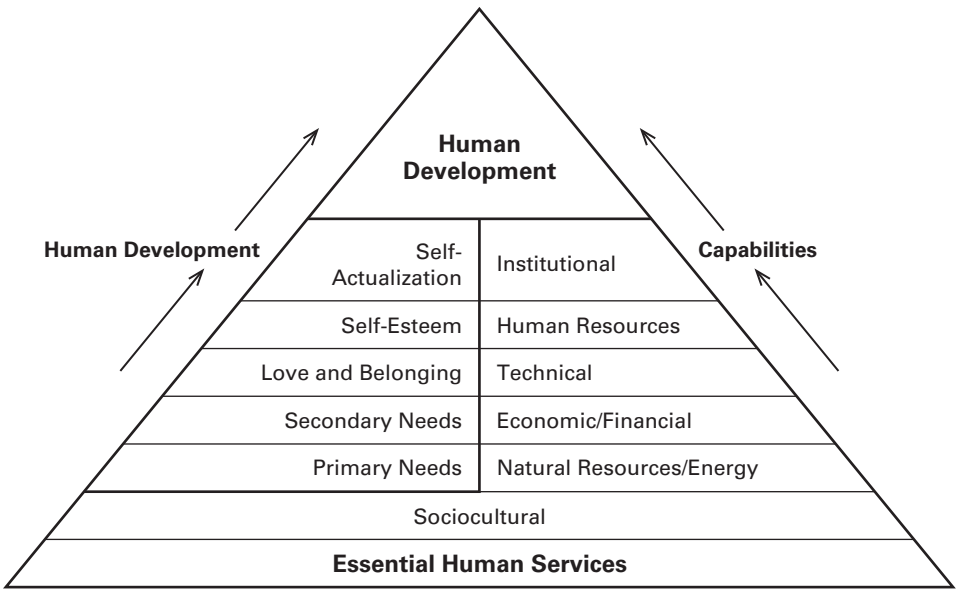

Figure 8.2
A human development model of capabilities. *Source:* Author.

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human development. This is in response to Rutledge's (2011) critique of Maslow's omission of the important role of social networking in human development (Rutledge 2011).

A lack of access to basic needs compromises efforts to provide for higher-order needs and short-circuits strategies for development. For example, lack of access to an adequate quantity and quality of safe drinking water and sanitation (*watsan*) results in an estimated 1.8 million child deaths and the loss of 443 million school days each year. In SSA, it causes an estimated annual GDP loss of 5 percent, or $28.4 billion (UNDP 2006c). According to UNDP, "Research in sub-Saharan Africa suggests that women and girls in low-income countries spend 40 billion hours a year collecting water" (UN Women 2009, 36; see also UNDP 2006a). This time could be spent on other, more productive activities that empower women and girls. Thus, the lack of primary services (watsan) compromises secondary services (health, education, productive employment) and produces losses that inhibit economic and ultimately human development (OECD 2012). Note that we define *employment* as income-earning activity.

Countries Must Build Domestic Capacity for EHS as a First Step toward Development

Countries need domestic capacity in order to assure sustained delivery of EHS to their people. For example, a lack of qualified local human resources may result in the failure of the water supply system to deliver its designed quantity of water and maintain its quality of service over time. This may be simply due to inadequate or inappropriate operation and maintenance (Davis and Brikké 1995; Brikké 2000). Reliance on foreign personnel to design, build, operate, and maintain local services can be expensive and may be unreliable if that talent, with no ties to the local community, is drawn away by more lucrative service contracts elsewhere. A case from the New Partnership for Africa's Development (NEPAD) is illustrative: NEPAD's Program for Infrastructure Development in Africa (PIDA) has an estimated capital cost of US$360 billion by 2040, with a cost of $68 billion expected by 2020. However, it has a present funding gap of US$31 billion (Commonwealth Business Council 2013). NEPAD does not specify what percentage of these projects will be implemented and/or managed in the long term by African, domestic private, or public sector entities. However, in a 2005 report on NEPAD's Short-Term Action Plan for Africa's Infrastructure, the African Development Bank noted that none of the expected US$7.1 billion in domestic private sector investment had materialized (UNDP 2006b). This indicates a need for local financial capacity building in NEPAD's plans.

More broadly, one may argue that it is not possible to sustain higher-order development processes like manufacturing without reliable basic services, such as water and sanitation. These essential services require a robust domestic capability to operate, maintain, and manage their associated infrastructure. In many cases in Africa, this capability is inadequate to meet current demands and must be developed.

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Capacity Building Is an Effective Innovation for Development Framework

We define *capacity* broadly in terms of the eight factors that determine sustained access to water and sanitation services. These capacity factors are summarized in table 8.3 (Brikké and Bredero 2003; Louis and Bouabid 2006).

The capacity factors can provide an effective framework for assessing the IfD needs. For example, table 8.4 compares the capacity factors to the Millennium Development Goals as frameworks for assessing the likely effect of innovation on national development objectives. A country could seek innovative ways to accomplish the MDGs in the expectation that this would also improve its citizens' access to primary and secondary services. For example, table 8.4 illustrates that innovation exclusively in pursuit of Goal 1, the poverty and hunger goal, is not likely to increase access to shelter, nor improve indoor air quality, and will have only questionable effects on increasing personal security. Innovation in pursuit of Goal 1 also is not likely to improve access to the secondary services of electricity, communication, transportation, and national security. Institutional innovation will facilitate sustained access to shelter and to employment; innovation directed at eliminating extreme poverty and hunger will not improve access to shelter, but will improve access to employment.

This suggests that a focus on innovative capacity building for each of the factors shown in table 8.4 (and defined in table 8.3) can serve a larger number of primary and secondary needs than a development strategy based on the MDGs. Other national or global strategies can be evaluated using the capacity factors as well.

The Yes (Y), No (N), and Questionable (?) cells in table 8.4 have been filled in subjectively by the authors, but work is under way to complete this table with empirical results for water and sanitation. The capacity factors are offered as an objective, systematic method for national self-assessment and prioritization of the innovation effort aimed at *clearly defined targets* in the form of primary and secondary human services. The assumption is that a solid domestic capability to assure sustained access to these services will be the foundation for access to the higher-level objectives of human development. The Sustainable Development Goals of 2015 can provide more clearly defined targets for this strategic capacity and capability building.

Table 8.3
Capacity factors for sustained delivery of essential human services

Capacity factor	Explanation
1. Institutional/governance	Policies, programs, processes
2. Human resources	Professional, technical, administrative, labor
3. Technical	Support services, supply chain
4. Economic/financial	Budget, taxes, fees, private providers
5. Environmental/natural resources	Stock of resources, consumption/recharge rates
6. Energy	Grid electricity, other sources, intensity, reliability
7. Sociocultural	Participation rate by gender, caste, class
8. Service	Quantity, quality, accessibility, reliability

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Table 8.4
Comparison of capacity factors and MDG for IfD planning*

	Primary needs														
Capacity factors	Water		Sanitation		Shelter		HH Energy		Indoor Air		Food		Pers Security		**MDG**
Institutional	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	?	Povt/Hunger
	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y	N	Y	N	
Human Resource	Y	Y	Y	Y	Y	Y	Y	Y	Y	?	Y	Y	Y	Y	Primary Ed
	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	N	
Technical	Y	Y	Y	Y	Y	?	Y	Y	Y	Y	Y	Y	?	Y	Gender/Womn
	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	?	
Econ/Finance	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	?	Y	Chld Mort
	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	
Envt/Nat Res	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Matnl Health
	Y	Y	?	Y	Y	Y	Y	N	Y	Y	Y	?	?	?	
Energy	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	Y	HIV/AIDS+
	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	?	
Sociocultural	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Envt Sustain
	Y	Y	Y	?	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	
Service	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Global Partner
	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
	Health		Education		Employ		Electricity		Communication		Transport		Nat Security		
	Secondary Services														

*HH—Household; Y—Yes; N—No; ?—Questionable; Employ—Employment; Pers—Personal; Nat—National; Povt—Poverty; Ed—Education; Womn—Women; Chld—Child; Matnl—Maternal; Mort—Mortality; Envt—Environment.

Foreign Aid Impedes Africa's Development

Aid dependency in Africa has long been widely debated in the literature. Bräutigam and Knack (2004) provide an insightful analysis with a focus on governance. Stampini, Salami, and Sullivan (2009) examine the performance of ODA in the water and sanitation sector. Moyo (2009) makes a forceful critique of foreign aid in Africa and proposes a formula of 5 percent aid, 30 percent trade, 30 percent foreign direct investment, 10 percent from capital markets, and 25 percent from remittances and directed domestic savings as a self-determinant strategy for financing development. Andrews (2009) conducts a limited literature review and concludes that greater attention should be paid to sociocultural factors to explain the mixed performance of official overseas financing (OOF) in Africa. We will not repeat this debate in this chapter; instead, it is instrumental to summarize the main points with respect to strategic *African* innovation:

- ODA comes with conditions that can favor the donors at the expense of the recipient.
- The different forms of ODA are not always consistent with long-term development planning.
- ODA dampens the incentive for domestic IfD by suppressing the different forms of capacity.

Now, we will briefly consider each of these points in turn.

ODA Comes with Unfavorable Strings Attached

Bilateral and multilateral aid to Africa often comes with requirements that are favorable to the donor but may be unfavorable to the recipient country. These include requirements that the recipient purchase supplies or services from donor country vendors, which may not offer the most competitive prices or appropriate goods and services. In addition, ODA does not consistently remove barriers of entry to products from the aid recipient country, which remains open to products from the donor country. In addition, structural adjustment requirements may attempt to direct the types of socioeconomic programs on which funds may be spent; may not reflect the priorities of sovereign, democratically elected local governments; and thus can have a politically destabilizing effect. An illustrative example is Glennie's (2011) report on the decline of the cotton industry in Mali due to subsidies paid to cotton farmers in donor countries. Loans required Mali to privatize its cotton industry, though it could not provide comparable subsidies to private farmers in Mali. Thus, Mali cotton could not compete by price on the open market with cotton from subsidized farmers in the donor country.

Moyo (2009) cites the example of the US$15 billion in aid from the US president's Emergency Plan for Aids Relief in 2003, which set aside two-thirds of funding for proabstinence programs and restricted the use of funds by organizations that provided abortion services. Such restrictions disregard the cultural preferences or public health priorities of the recipient

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country. In large infrastructure projects like the Lesotho Highlands Water project, implementation can be dominated by foreign companies from OECD countries and non-OECD countries like China (Bräutigam 2010; Mwangi 2007; Zawdie and Langford 2002).

In essence, African countries borrow money from International Development Banks, then use the loan funds to pay companies from the donor countries to do the work. If this process yielded residual domestic capacity in Africa to manage the resulting projects and implement future ones, it could be seen as a form of investment in necessary capacity building. However, there is little evidence that this form of capacity building occurs. Instead, the debt from these projects is associated with a continuing cycle of dependency by Africans on foreign financing and technical and management resources. This is a model for neither African innovation nor African development.

Different Forms of ODA Are Inconsistent with Development Planning

Figure 8.3 summarizes the trends in foreign aid to Africa by type and as a percentage of GDP from 2000 to 2014 (projected). It shows that total OOF to Africa reached a high of just over 12 percent of GDP in 2006, experienced a decline concurrent with the global financial decline in 2008, and has remained fairly steady at roughly 9 percent of GDP since then. ODA has declined from a high of 42 percent of OOF in 2003 to a projected low of 27 percent in 2014. The percentages are higher for the twenty-seven countries in Africa ranked as low-income by the World Bank.

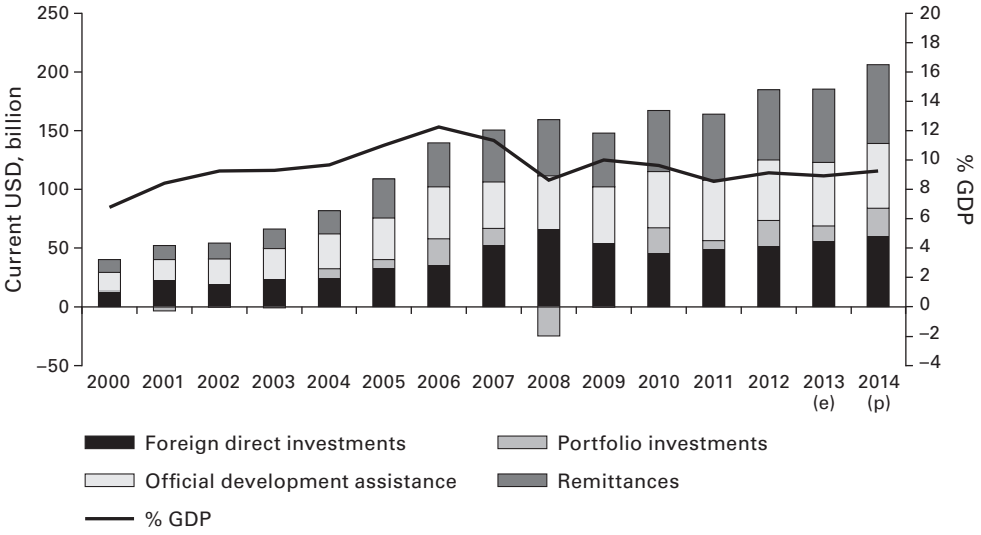

Figure 8.3
External financial flows to Africa, 2000–2014.
Source: African Development Bank, OECD, and UNDP 2014.

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Humanitarian aid and charity-based aid are often specified for emergencies or for specific social benefit projects identified by charities. Emergency aid (food, medicine, temporary shelter, and the like) and charity-directed aid are sporadic in timing, type, and quantity and not amenable to systematic long-range planning for development. Systematic aid, both bilateral (government to government) and multilateral aid (from the World Bank and regional development banks) could foster development if tied to clearly identified projects with specific development goals, strong accountability systems, and careful planning for the generation of returns from the projects that cover loan and interest payments plus operation and maintenance costs (Moyo 2009). Unfortunately, this has not commonly been the case in Africa (Bräutigam and Knack 2004). Finally, fragmentation caused by a large number of foreign aid projects that overwhelm the management capacity of the recipient government can be a limit to the effectiveness of OOF.

ODA Suppresses Domestic Capacity Building

Foreign aid dependency can diminish local capacity building and innovation for development. First, ODA can exacerbate historically weak governance by removing the need for multistakeholder negotiations over taxation and budgets, by removing accountability for revenues, and by bolstering regimes that would otherwise not be able to retain power (Moyo 2009; Toïngar 2014). Second, ODA—either in the form of concessional loans, which are routinely forgiven, or grants, which do not have to be repaid—can serve as a form of insurance for governments that subsequently undertake projects with higher risks of failure than they would otherwise consider and exert less effort when collecting tax revenue to finance government expenditure. In effect, ODA creates a form of moral hazard in recipient countries. Hence, ODA can suppress institutional capacity building. Third, technical assistance on aid projects often uses foreign advisors, who may come at a higher cost to the project than locals, and this also restricts the number of locals trained to implement and ultimately take ownership of projects. In this way, ODA can suppress local human resource capacity building. To the extent that these projects poach scarce local expertise from government agencies and the domestic private sector by offering higher salaries, they further stifle local human resources and financial capacity building in the private sector.

Table 8.5 shows the estimated percentage of government expenditure provided by ODA in selected African countries in 1999. Although this data is fifteen years old, it remains in question how much this level of external aid and its potentially inhibiting effects on autonomous African development planning has diminished. Prolonged, high levels of financial aid and technical assistance can diminish opportunities for domestic personnel and agencies to learn from experience and innovate, which are integral aspects of capacity building.

Examples of Innovation for Development for Watsan Services

Table 8.6 lists a few examples of capacity-based innovation in the provision of water and sanitation services that are part of the first step toward human development in a country. It

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Table 8.5
ODA as percentage of government expenditure in selected SSA countries, 1999 (Bräutigam and Knack 2004)

Country	%	Country	%
Rwanda	99	Senegal	54
Malawi	89	Uganda	51
Mauritania	87	Benin	51
Sao Tome and Principe	84	Djibouti	47
Zambia	72	Sierra Leone	45
Cape Verde	67	Comoros	45
Guinea Bissau	67	Burundi	43
Chad	65	Guinea	41
Central African Republic	63	Ethiopia	37
Tanzania	62	Gambia	36
Niger	58	Ghana	30
Burkina Faso	57	Togo	27
Mali	55	Cameroon	25
Madagascar	54		

Table 8.6
Examples of innovation in the sustained delivery of watsan services

Capacity factor	Innovation example
Institutional	Village water and sanitation committees (Stalker, Abyankar, and Iyer 2001)
Human resources	Global Water Operators Partnership Alliance (UN Habitat; GWOPA 2014)
Technical	Point-of-collection chlorine dispenser system (Innovations for Poverty Action; IfPA 2015)
Economic	Maji Ni Maisha, Global Partnership on Output-Based Aid, Kenya (World Bank 2010b)
Environmental	WaDImena* (IDRC 2004)
Energy	Solar Electric Light Fund (SELF 2015)
Sociocultural	Community-Led Total Sanitation (CLTS 2011)
Service	Aakash Ganga rainwater harvesting system ("Aakash Ganga" 2009)

*Water Demand Management Initiative—Middle East and North Africa.

is important to note that IfD in Africa by Africans can also build on innovations generated outside of Africa and by non-Africans. For example, automobiles were not invented in Africa, but that does not mean that Africans cannot find innovative ways to use automobile transportation systems to further development in Africa.

Institutionale

Village water and sanitation committees (VWSCs) are an example of innovation in the institutional capacity factor, because they can provide an alternative to absent or less effective government agencies in gaining access to improved watsan services, particularly in rural

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areas. The World Bank's Water and Sanitation Program—South Asia studied the effectiveness of VWSCs in the states of Karnataka and Uttar Pradesh, India. They found that four features were important for effective VWSCs: *Transparency* is openness of the decision-making and management processes to villagers; *participation* refers to a representative mass of community members who understand the benefits of the project and set the rules of engagement; *inclusion* is the opportunity for all subgroups and households to contribute to the project and receive its services; and *ownership* is the community's sense of stewardship for the infrastructure and its sustained operation and maintenance. The study found that VWSCs were effective in implementing watsan projects, that community members were generally satisfied with the projects and services they delivered, and that villages in Uttar Pradesh were able to bypass the traditional regional government in implementing and managing their watsan system (Stalker, Abyankar, and Iyer 2001).

Human Resources

The human resource capacity factor addresses the availability and capability of individuals to build, operate, and maintain watsan services. The Global Water Operators Partnerships Alliance (GWOPA), hosted by UN Habitat, facilitates peer support arrangements between watsan operators and organizations to share knowledge and tools that can help sustain and improve the performance of water and sanitation systems.[3] Agua Para La Vida (APLV), a nonprofit organization operating in Nicaragua, aids in the development of rural, community-based, gravity-fed water systems. APLV trains water system builders at its facility in Rio Blanco, Nicaragua. These builders then provide technical expertise and leadership to help communities build small water supply systems. During the construction process, APLV personnel train community members to operate and maintain the systems so that they will remain in service after APLV has withdrawn. Over twelve thousand people have been reached through APLV's efforts to date.[4]

Technical

The technical capacity factor refers to the supply chain for producing the service along with the necessary spare parts and support services for sustained operation and maintenance of the system. Despite the availability of inexpensive bottled chlorine (less than 0.3 dollars per month for a family of five) in rural Kenya, its use for disinfection of drinking water in households remains low. Hiring local promoters has a temporary effect on household chlorination, but rates then fall off again. The point-of-collection chlorine dispenser system is a device for dispensing a diluted chlorine solution from standpipes and other public water-dispensing services to improve access to disinfected water in communities that do not have water piped into homes. The system has been implemented in Western Kenya. Installment of these dispensers at points of water collection has led to an increase in the use of chlorinated drinking water by 52 percent in targeted communities; as the technology became easier to use, people were influenced by their neighbors who were using it. The cost of dis-

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penser hardware, refill, maintenance, and management is less than 0.5 dollars per year per person, which is much lower than the home delivery bottled method. Furthermore, the entire project is run through a close partnership with local NGOs, local manufacturers, and local managers, which greatly increases local capacity to sustain the system (Poverty Action Lab 2015).

Economic and Financial

Maji Ni Maisha (Water Is Life; MNM) is a financing program for small- to medium-scale water projects in Kenya. The scheme consists of four major stakeholder groups: (1) the community acquiring the water project, including its contracting water service provider; (2) K-Rep Bank, which provides and manages the loan for the water project, drawing from funds in a trust supported by the World Bank and European Union; (3) government regulators that control the water extraction, environmental impacts, and the water service provider; and (4) support organizations that help the community apply for the loan, contractors that design and build the system, and others that monitor the performance of the project with respect to its targeted number of users served.

The MNM process consists of three major steps: (1) a detailed loan qualification and disbursement process, which includes 20 percent of project costs deposited by the community; (2) project implementation by a contractor—selected as a requirement of the loan; and (3) postimplementation operation and management by a contracted service provider, output target verification, and payment of a government subsidy to the community to reduce the total amount of the loan.

K-Rep Bank works with regional water service boards across Kenya (K-Rep Bank 2010). Its detailed attention to loan qualification by communities, the use of contracted service providers, and the requirement of achieving water service output targets to receive a government subsidy suggest that MNM is an innovative approach to providing water service to communities that are willing and able to pay the final subsidized cost. Not all communities meet these criteria, but MNM can be a worthwhile model for those that do. From 2008 to 2013, MNM financed thirty-five water projects to the tune of KES$415 million (around US$4.4 million), benefitting almost 220,000 people (Otuki 2013).

Environmental and Natural Resources

The Water Demand Initiative in the Middle East and North Africa (WaDImena) is a regional water resource–management and conservation program serving the water-scarce countries of the Middle East and North Africa (MENA). This multifunded program was initiated in 2005 to foster innovative solutions for water-usage efficiency, equity, and sustainability in these countries. It emphasizes a participatory approach of close relations between local people and government, encouraging an exchange of experience and knowledge in order to find the most appropriate solutions to regional water demand and to build individual and institutional capabilities (Lahlou and Attia 2005; Soer and Lebdi 2011). For instance, one of these

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projects is reviving an old Yemeni practice of reusing gray water from mosques for crop irrigation (Khaled 2007).

Energy

The Solar Electric Light Fund (SELF) is a not-for-profit organization founded in 1990 by Neville Williams and based in Washington, DC. SELF helps to provide affordable, village-wide solar electric systems to rural communities that lack access to grid electricity. Using its Whole Village Development Model, SELF addresses other needs in the community that require electricity, including drip irrigation for crops, refrigeration, and online learning. Since 1990, SELF has worked with partners to bring modular electricity to villages in twenty countries worldwide, providing innovative access to electricity in rural villages (Wood 2013). Africans can adapt the SELF model to extend decentralized electricity services to other off-the-grid communities across the continent as an example of African IfD based on a technology developed outside of Africa.

Sociocultural

Community-Led Total Sanitation (CLTS) is a self-help program pioneered by Atul Wad in 2000; it increases sustained access to improved sanitation services for communities in Bangladesh and elsewhere. CLTS uses trained facilitators to engage community residents in recognizing the dangers and undesirability of open defecation in their villages. Residents receive guidance on how to develop sanitary defecation habits and install the necessary infrastructure. When they have done this, the community is awarded the *open defecation–free* status. CLTS has now spread to India, Indonesia, and parts of Africa. CLTS makes innovative use of social marketing and participation to achieve widespread, sustained access to improved sanitation services (Kar and Chambers 2008). It can be adapted to work in Africa by Africans.

Service

Service capacity or *capability* refers to the quantity and quality of a service as well as its accessibility (distance, price, terrain) and reliability (percentage of scheduled demand available). Aakash Ganga (*river from the skies*) is a public-private-community partnership that uses rainwater harvesting to provide sustained access to drinking water in Rajasthan State, also known as India's *desert state*. B. P. Agrawal, the driving force behind the project, assembled a partnership of state and local governments, villages, local university resources, and NGOs to implement the initial project with a $200,000 grant from the World Bank's Development Marketplace. The project carefully integrated local customs and social practices to assure equitable usage fees and access to water services, which allows villagers to meet their water needs for ten to twelve months per year instead of depending on more expensive, lower-quality, truck-borne government water supplies. The project generates a small surplus in revenue, and evidence is emerging that in the villages served by these water schemes, there is a higher level of school attendance by girls, and homes are able to grow small vegetable

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gardens. Aakash Ganga is now being considered for broader expansion across Rajasthan and is being considered by the Guiyang Municipality of Guizhou Province, China ("Aakash Ganga" 2009).

Conclusion

This chapter argues that African countries can set their own agendas for development by prioritizing primary and secondary human services, developing innovative ways to build their broad-based capacity, and selectively and strategically using foreign aid. The premise is that building domestic capacity for sustained access to essential human services is the first step on the ladder to personal and national human development. The chapter presents human development as the realization of a person's full potential in society, enhanced by the availability of choice, freedom, and social networks and capabilities necessary for satisfying a person's needs and exploiting available opportunities. What this implies, but does not articulate, is that the aggregate of a systematic approach to development by individual countries will produce the type of innovation that leads to sustainable human development, driven by Africans across the continent of Africa.

Notes

1. This discussion centers on human development. It assumes that technological and economic development are means to achieve the goal of human development.

2. *Capacity* is the potential to meet a need, such as the amount of water in a river. *Capability* is the means to meet the need, such as pumping and piping the water to its point of use.

3. See http://www.gwopa.org.

4. See https://aplv.org.

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9
Science, Technology, and Innovation in Africa: Conceptualizations, Relevance, and Policy Directions

Chux Daniels

The field of science, technology, and innovation (STI) is an engine of growth in any economy. Realizing that Africa can also benefit from STI activities, in 2005 the African Ministerial Council on Science and Technology (AMCOST) adopted Africa's Science and Technology Consolidated Plan of Action (CPA), which articulates the African Union (AU) agenda for harnessing STI to boost economic growth and improve the lives of African people. (NEPAD[1] 2014, xxviii)

It is generally accepted that STI contributes to growth, socioeconomic development, and the competitiveness of nation states (Juma 2005; Kraemer-Mbula and Wamae 2010; UNCTAD 2014). This notion, and the realization of STI as an engine of growth, has become so widespread that few words and phrases surpass *innovation* in modern-day science and technology (S&T), development, or policy discourse, and this holds true in Africa as well. We find such evidence, for example, in the new ten-year *Science, Technology and Innovation Strategy for Africa 2024* (STISA-2024) document "On the Wings of Innovation" (STISA 2014). There are also promises of similar strategies and policy documents in the months and years to come, such as the formulation of "a broader and long-term AU Agenda 2063" strategy leading up to the AU's hundred-year anniversary (STISA 2014, 10). It is therefore arguable, on the basis of this AU long-term strategy, that STI will continue to play a center-stage role in Africa in the foreseeable future.

In line with this center-stage role for STI in Africa, various collaborative efforts have been initiated at both AU and regional levels aimed at supporting, promoting, and applying STI as an instrument for development (Mugabe 2009)—with varying degrees of success and challenges: "The challenges are how to link science, technology and innovation to poverty reduction, job creation, sustainable livelihoods and the improved well-being of citizens. How should capacity and competencies be built in order to innovate? As countries engage in knowledge intensive activities, how will Africa expand its knowledge?" (NEPAD 2014).

NEPAD's statement aptly captures the concerns of many scholars and technocrats in their attempts to better grasp Africa's development challenges through the STI lens. In this chapter, I argue that some of the reasons that these attempts have yielded less than optimal results

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lie in the way STI is conceptualized in the continent, an inability to make STI relevance felt by the wider society, and weaknesses in STI (including public) policies.[2]

The AU, in STISA-2024, identifies (some of) the STI priority areas for Africa:

> Eradication of Hunger and Achieving Food Security; Prevention and Control of Diseases; Communication (Physical and Intellectual Mobility); Protection of our Space; Live Together—Build the Society; and Wealth Creation. The strategy further defines four mutually reinforcing pillars which are prerequisite conditions for its success. These pillars are: building and/or upgrading research infrastructures; enhancing professional and technical competencies; promoting entrepreneurship and innovation; and providing an enabling environment for STI development in the African continent. (STISA 2014, 10)

These challenges or variations thereof are echoed across Africa in regions and in individual nations. Nonetheless, substantial gaps remain in our knowledge of suitable approaches to addressing challenges in areas such as STI understanding, definition, and conceptualization (Aubert 2005; Foster and Heeks 2013); innovation ecosystems, like institutions, landscape dynamics, and actors, which can ensure effective interactions and partnerships (Adebowale 2012; Kruss 2012; Kruss et al. 2013); and the capabilities, knowledge, and learning required to achieve Africa's STI aspirations (Marcelle 2004; Berdegué 2005; Bell 2007; Oyeyinka 2012). Furthermore, the relevance of STI to African societies, rich and poor (Lorentzen and Mohamed 2009; Cozzens 2010) and the indicators and measurement methodologies and frameworks required (Arocena and Sutz 2010; OECD 2012; Sutz 2012; Daniels 2014), in addition to the policy instruments, policy mix, and policy frameworks needed to address these challenges, remain somewhat elusive (Mugabe 2009; World Bank 2010a; OECD 2013; Phiri et al. 2013; Daniels 2015; UNDP 2014; UNCTAD 2014).

There is also the need to ensure that STI can help tackle these challenges and realize the development priority areas outlined without exacerbating poverty, inequality, and social exclusion (Cozzens and Kaplinsky 2009; OECD 2012; Hart, Jacobs, and Mhula 2013; Scerri and Lastres 2013; World Bank 2013). Although access to basic education and services[3] continue to improve in Africa, indicating a decline in poverty, unemployment continues to rise, and "inequality remains extreme" across some parts of the continent (UNDP 2014, 6). Ultimately, the goal must be to ensure that Africa's core interests remain top in the agenda (Muchie, Gammeltoft, and Lundvall 2003). To achieve this requires a critical examination of what science, technology, and innovation mean from Africa, for Africa, and to Africa: STI through the lens of Africans themselves.

With much hope resting on the ability of STI "to impact across critical sectors such as agriculture, energy, environment, health, infrastructure development, mining, security and water among others" (STISA 2014, 10), it behooves us to look closer into what STI means from Africa. What are the current definitions of STI in Africa? How is STI conceptualized, theorized, and applied in addressing these development challenges and priority areas that are now taken for granted in academic circles? What is included or excluded in the STI black box in Africa? Who controls the narrative? What development trajectories have been identified,

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and how are they being addressed? How is the current brand of STI in Africa (potentially) effective in tackling not just the needs of the elite, high and mighty multinationals and big firms, but also the poor and rural dwellers, "grassroots" innovators, small and medium enterprises (SMEs), and entrepreneurs below the radar or at the base/bottom of the pyramid? How do we ensure that STI delivers on its promises in Africa?

In this chapter, I argue that the potential of STI to contribute to Africa's socioeconomic development hinges to a large extent on what STI means from an African perspective or in an African definition, how it is conceptualized and operationalized, and the impact of policies targeted at STI. I argue that these factors have bearing on the relevance of STI to addressing societal needs.

The History and Development of Science, Technology, and Innovation

Some key scholarly works and academic disciplines have influenced the way science, technology, and innovation are currently defined, theorized, and conceptualized. In tracing the origins and evolution of innovation studies, Martin (2012a) identifies the key intellectual developments in the field over the last fifty years, reveals how it drew upon a range of disciplines in the late 1950s and 1960s, and how it has continued to evolve. The author adds: "Around the mid-1980s, substantial parts of innovation studies started to coalesce into a more coherent field centered on the adoption of an evolutionary (or neo-Schumpeterian) economics framework, an interactive model of the innovation process, and the concept of 'systems of innovation'" (Martin 2012a, 1219).

In addition to Schumpeter's seminal work on innovation, other key works that have shaped this field include the National System of Innovation (NSI) framework (Freeman 1987; Lundvall 1992; Nelson 1993); evolutionary economics; the theory of economic change, routines, skills, and capabilities (Nelson and Winter 1977, 1982); technological paradigms and trajectories (Dosi 1982); sectorial taxonomy of technical change (Pavitt 1984); and structural crises of adjustment (Freeman and Perez 1988). Others include absorptive capacity (Cohen and Levinthal 1990); technical change; rates of return to R&D (Hall, Griliches, and Hausman 1986; Griliches 1990); diffusion of innovation (Rogers [1962] 2003); innovation and entrepreneurship (Drucker 1985); technological capabilities (Marcelle 2004; Bell 2009); and others on growth theory and technological change, catch-up, falling behind, and so on.

More recently, we find contributions and influences from newer streams of research, such as *inclusive innovation* (a term used in this chapter to cover the wide spectrum of innovation at grassroots, social, frugal, imitative, and reverse innovation [Gupta et al. 2003; Gupta 2012; Fressoli, Smith, and Thomas 2011; World Bank 2013; Daniels 2015; Smith, Fressoli, and Thomas 2014]), the "triple helix" (Etzkowitz and Leydesdorff 2000); measurements of innovation studies and practice; the *Oslo Manual* (OECD and Eurostat 2005); open innovation (Chesbrough 2003); democratizing innovation and user innovation (von Hippel 2005); sociotechnical studies and transitions (Geels 2004); and many others.

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Empirical evidence provided in Martin 2012a indicates that other works from "outside" innovation studies or from "neighboring" domains that have had considerable influence on the field include works on organizations (March and Simon 1958), resource-based views of firms (Penrose 1959), paradigms (Kuhn 1992), knowledge (Polanyi 1966), competitive strategy (Porter 1980), and much more.[4] Since Schumpeter's seminal discussion of innovation in the context of economics and subsequent contributions from evolutionary economists, innovation studies have evolved to incorporate perspectives from a range of social science disciplines, such as policy studies, sociology, anthropology, management, history, public administration, organizational studies, and business (for more on these, see, e.g., Martin 2012a).

A revisit of this brief historical account is helpful in debunking the myth and often misplaced attention on the idea of advanced R&D and S&T (or basic science) as the predominant (and sometimes the only) source of innovation in Africa and the Global South. This tendency toward exclusivity of the S&T-centric approach in innovation studies has sadly become the predominant narrative and framing of STI in Africa—contrary to the evidence that it does not explain the totality of innovation activities or sources. It therefore distorts the collection and interpretation of data, fuels the assumption that there is little innovative activity in Africa, and impacts the meaning of STI from Africa.

Consequently, the point being made in this section is that although some domains have played "major" roles in the development of innovation studies, there is a need for new and different perspectives in Africa that are not effectively captured by current research, policy, and practice—resulting in weakness in the way STI is conceptualized in Africa, the relevance of STI, and policy focus. Therefore, the exclusion of contributions from "minor" fields in innovation studies and the focus on S&T-centric innovation only weakens the potential contributions of innovation to development and its role in addressing societal challenges. This point has important bearing on the meaning of STI from Africa, particularly in terms of how STI is defined, what counts (or not) as STI, and what is included or excluded in STI measurements.

The examples in boxes 9.1 and 9.2 show cases of STI from Africa defined primarily in terms of R&D, product and process innovation, and S&T-centric indicators such as patents, science publications, and citations, R&D expenditure (percentage of GDP), number of researchers, labor force with tertiary education, and so on (see, e.g., AOSTI 2013; and Vroh 2014). Unfortunately, these narrow framings of STI in Africa are propagated in part by both small and large institutions alike, including the AU establishments. One outcome of such "endorsements" unintended as they may be, is the imposition of the dominant "Western" narrative and induced innovation directionality, which favors innovation by means of R&D in formal institutions, big science, and innovation driven by advanced S&T. This approach neglects innovation in the informal domain, such as inclusive (and grassroots) innovation, that incorporates indigenous knowledge and learning practices.

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Box 9.1

For one practical example, consider the case of Nigeria's 2012 STI policymaking. The fastest growing sector in the economy over the last two decades (the movie and entertainment industry) was not regarded as STI and not included in policymaking processes, nor were actors of this important sector consulted during policy formulation exercises (FMST 2012). This is despite the substantial number of jobs generated by this sector. Another positive impact of Nigeria's movie industry is its significant contribution to GDP growth, which enabled Nigeria to overtake South Africa and gain the status of Africa's largest economy.

Box 9.2

M-Pesa is a mobile payment system that is revolutionizing mainstream banking not only in Kenya, but in the rest of the region, with the potential for continental and global reach and implications. In contrast to Nigeria's movie industry, with significant instances of social, organizational, process, and marketing innovation, M-Pesa is more easily recognized as innovation, because it is an S&T-based, technology-driven example of product innovation.

The case of M-Pesa demonstrates that the nature of innovation in developing country settings extends beyond conventional product and process innovation, because such innovations take advantage of extensive, complex, volatile, embedded networks of actors to facilitate diffusion, a process that in itself requires technical and social innovation (Foster and Heeks 2013). Achieving commercial success is pegged on a deep understanding of local culture, social networks, and indigenous knowledge. I reiterate here the importance of widening the scope of STI studies in general and tackling the challenges in operationalizing the relevant frameworks (e.g., NSI [discussed later], research, development, and policy frameworks).

Ahead, I will describe other factors that are useful in deepening the knowledge and understanding of what has gone before us. They shed light on why it is important for Africa to challenge the status quo rather than build on historical paths that are at odds with its development aspirations and philosophical underpinnings. Africa must redefine, reconceptualize, and theorize STI in a way that is relevant to its specific context and challenges. The continent must be willing to trust its own decisions (i.e., decisions made by those in authority). When applicable, Africa must be willing to chart a different STI and development trajectory if necessary.

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The beginnings of innovation studies and the development of the resultant concepts have also been shaped by global events such as World War I and II and the race for technological superiority and dominance that ensued, with an "emphasis on basic science and defense" (Shapira and Kuhlmann 2001, 2). This emphasis gave rise to the use of S&T as a national competitive tool—rather than as a source of development and cooperation, which would currently be more favorable to Africa. In spite of these influences, the consensus is that there is increased awareness of STI not for defense, technological superiority, and competitiveness, but for broadened policy goals and societal development that is inclusive, strives to reduce poverty and inequality (Freeman 1991; Shapira and Kuhlmann 2001; Kaplinsky 2011a, 2011b), is friendlier to the environment, and promotes sustainable practices. To achieve these aims, innovation will need to be transformed.

Freeman (1991, 1), in analyzing this evolutionary trend—that is, the shift from science to technology and innovation with an emphasis on the quality of life—sums it up as follows:

> During the lifetime of SPRU,[5] the emphasis in science and technology policies has shifted from an essentially science-push framework in the 1950s, through a phase of preoccupation with economic growth and management of innovation in the 1960s, and on to a wider concern with the environment and quality of life since the 1970s. Within this context, some quality of life issues are discussed which are only indirectly related to economic growth: civil liberty, quality, variety and choice in new products and services, and social equity. A number of examples are given of changes in trend which are influenced by, and sometimes closely related to, changes in science and technology, which give some grounds for hope.

The National System of Innovation (NSI) framework has had a significant influence on innovation studies (Freeman 1987; Lundvall 1992; Nelson 1993). The NSI was introduced to help explain differences in the adoption and rate of technological changes between nations—that is, why some countries experience greater technological dynamism than others. Although the NSI is widely utilized in innovation studies and has proved useful, its application particularly in Africa and the Global South[6] has been growing (Johnson, Edquist, and Lundvall 2003). Some of the major critiques of the NSI framework include its focus on formal institutions; promotion of R&D and science-based activities as predominant sources of innovation; and a bias toward firms (i.e., the centrality of firms as engines of innovation), with less attention on nonfirm innovation sources that are equally important (if not more relevant) in Africa. Kraemer-Mbula and Wamae (2010), Foster and Heeks (2013), and Iizuka and Sadre Ghazi (2011) make these arguments. Other arguments against NSI include its focus on formal knowledge sources while neglecting indigenous knowledge and learning, along with a preference for radical rather than incremental novelty in terms of "new" products and services—as opposed to improvements in the value and quality of life (Freeman 1991).

In spite of these shortcomings, the NSI framework has remained the dominant framework for understanding and analyzing national innovation activities in both academic and

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policy circles. The implication is that the NSI determines to a large extent how STI, and innovation in particular, is defined, conceptualized, measured (i.e., what is included in the definition, counted or not counted, and determined by measurement indicators) in Africa. Given its weaknesses, a well-articulated research agenda focused on the review of, for example, the NSI and the triple helix in ways that ensure it better captures the practical realities of STI in the continent's priorities is therefore essential if STI is to have the right meaning, influence, and relevance in Africa. A culture or practice that allows scholars to apply the NSI framework without incorporating Africa-centric issues must be challenged and discouraged. This is essential for optimizing the contributions of STI to development in Africa.

Historically, innovation efforts in Africa have focused on R&D, referred to as the *First Frame* in innovation policy circles by some scholars. From R&D, we experienced a move to the NSI framework approach to innovation policies, the *Second Frame*. The emphasis is now on the *Third Frame* of innovation policy, with an emphasis on the need to transform, rethink, or reimagine innovation in a way that ensures that it is inclusive, does not exacerbate poverty, is friendlier to the environment, embeds sustainable practices, and focuses on addressing global (mega) challenges, as outlined in the SDGs, for example.

Africa: What We Already Know

The evidence gathered, the indicators used in capturing that evidence, the interpretation of the evidence, and the lenses (i.e., frameworks) through which the resulting knowledge and information about the continent are analyzed have a bearing on what STI means from Africa. Ahead, I will analyze the impacts of demographic changes, informal economy, education, and knowledge on Africa's STI and development.

Judging from the current data, the information in figure 9.1, and a variety of projections,[7] we find interesting trends with implications on the potential role for STI in Africa's development. A continent's population—from which the labor force and the market are drawn—are at the core of development. The available data indicate that by 2030 Africa's population will rise from one billion in 2010 to 1.6 billion, representing 19 percent of the world's total. There will be reduced child mortality and an increased average life expectancy, from fifty-seven (2010 estimate) to sixty-five years. A large young, active, and educated population presents the challenges of unemployment, political instability, and backlash but also opportunities for large workforces, markets, increased productivity, "global powerhouses," and many others (AFDB 2012). Drummond, Thakoor, and Yu, noting the importance of harnessing the demographic changes envisioned, write:

> Africa will account for 80 percent of the projected 4 billion increase in the global population by 2100. The accompanying increase in its working age population creates a window of opportunity, which if

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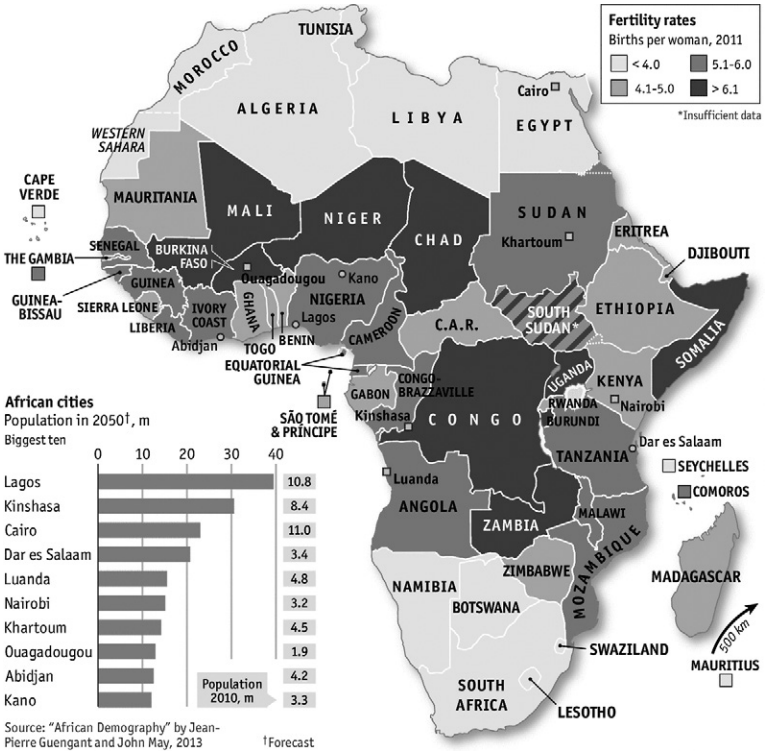

Figure 9.1
African demography: fertility rates.
Source: The Economist 2014.

properly harnessed, can translate into higher growth and yield a "demographic dividend."[8] It will be critical to ensure that the "right" supportive policies, including those fostering human capital accumulation and job creation, are in place to translate this opportunity into concrete economic growth. (Drummond, Thakoor, and Yu 2014, 2)

Such an increase in population calls for finding innovative ways to meet local needs that become even more pressing with the increase; thus, there is a need for policy, research, and practice to shift focus to interventions that take advantage of local resources (knowledge, capabilities, labor, local solutions, new or alternative STI and development indicators, etc.). This kind of shift requires a change in mindset. The importance of research, investments, and policy support for inclusive innovation (or innovation for inclusive development) that targets rural (grassroots) populations at the base of the pyramid is therefore heightened (Daniels 2015). This presents opportunities for STI that are adequately reconceptualized in a way that ensures that STI is relevant to wider societies.

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We know that a large section of the African economy is informal (ILO 2009, 2012; Charmes, Gault, and Wunsch-Vincent 2015). A significant amount of innovation activity in the continent, as in the wider Global South, draws from indigenous knowledge, occurs in informal settings, and is largely ignored in innovation, development, and management studies (Kraemer-Mbula and Wamae 2010; Godfrey 2011; Cozzens and Sutz 2012). Therefore, the definition, conceptualization, and meaning of STI from Africa must reflect this fact. Furthermore, STI measurement indicators need that capture innovation activities both from formal sectors (driven by R&D and advanced S&T-centric activities) and informal sectors (i.e., predominantly non-R&D focused). Evidence abounds that shows that both sources of innovation are critical to development. There is therefore the need for new and/or alternative STI measurement indicators to capture the full extent of innovation in Africa.

Attempts to understand STI in Africa must also take into account the nature of education. So far, formal curricula have focused on science, technology, engineering, and mathematics (STEM) in particular and also on technology and innovation management (TIM) courses,[9] thereby emphasizing technological capabilities. However, just as innovative activity in Africa is diverse, the underlying education systems are diverse too, featuring a mix of formal education in schools and institutions of higher learning, apprenticeship programs, and indigenous education that passes down tacit knowledge of innovative processes at rural and grassroots levels. Africa is knowledge-rich thanks to such a diverse educational system; STI education should be expanded to include these sources and reflect this diversity.

A few universities are beginning to teach creativity and entrepreneurship courses in Africa. STI and capabilities for policymaking curricula have to a large extent focused on physics, chemistry, biology, and mathematics. This practice has resulted in a large percentage of the educated population with academic qualifications in STEM courses struggling to find jobs that are nonexistent, rather than acquiring the knowledge and abilities to create jobs.

What picture does this conjure vis-à-vis the meaning of STI from Africa? What links to creativity, entrepreneurship, S&T, and innovation can be made? Review Farlon's story, presented in box 9.3. How would such linkages make STI more relevant to Farlon and the millions like him? Are such linkages possible and realistic? The bigger question is this: Why does the continent continue along a trajectory that produces millions of graduates in disciplines in which they cannot find work, thereby exacerbating unemployment, rather than equipping students with the tools to create jobs when jobs have not already been created for them? Five years after his university education, Farlon is still unemployed.

A paradigm shift in education is necessary in order to produce graduates who are equipped with the tools they need on completion of their formal education and know what it takes to convert their academic training in any chosen discipline into innovative and profitable businesses, self-employment opportunities, or global brands. Such a transformation in education

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Box 9.3

Farlon is a bright entrepreneurial African man. Growing up, he sang in the church choir, acted, and danced—evidence of his rich artistic skills. He was even more talented in fine arts—painting, drawing, design, and sculpture. Due to lack of funds, he could not continue his education. But being entrepreneurial, he set up a photography business. The money from this business enabled him to fund his university education. Farlon obtained a bachelor's degree in fine arts, graduating at the top of his class. On completion of his master's degree, he realized that even with his fine arts skills (arts, painting, and drawing), photography skills, and academic qualifications, he did not receive any training that could equip him with the know-how to sell his artwork and become an entrepreneur. The outcome? He joined the already overcrowded job search space with increasing disappointment and frustration as days turn into weeks, weeks into months, and months into years.

could potentially result in an explosion of innovation across the continent as graduates identify needs and apply their training (alone or in collaboration with other individuals, firms, civil societies, NGOs, or government agencies) to find innovative solutions that address societal challenges; by doing so, they can create jobs and foster economic socioeconomic development.

Related to education, as discussed earlier, is knowledge production and circulation. Informal education in Africa, such as by means of apprenticeship and craftsmanship, involves passing down tacit knowledge of innovative local practices (agriculture, sustainability, medicine, conservation, and so on), which could be drawn into an STI framing of knowledge generation and circulation. The implication is that the nature of social capital in Africa, if leveraged, may help in developing networks for collaboration and knowledge sharing.

Informal networks are sometimes valued more than formal networks in the continent. Although there are some disadvantages, they offer unique potential for development, as research evidence on clusters in Africa indicate (McCormick and Schmitz 2009). Therefore, although education and knowledge through formal sources are critical in shaping the meaning of STI from/in Africa, knowledge production, transfer, circulation, and "learning by doing," as is common with artisans and traditional craftsmanship, are also critical to innovation and inclusive development. As Richard Nelson (2015, ix) has observed: "A large share of innovation efforts fail; success requires a considerable amount of learning by doing and using before acquiring the needed innovation capabilities."

It is important to reiterate—and, by so doing, emphasize—that knowledge is knowledge, regardless of whether it is produced in Africa or the Global South or North. Innovation lies in the abilities of STI actors to convert, utilize [strategic] knowledge, and transform it into improvements in the provision of goods, services, processes, and practices that enrich the quality of life, thereby contributing to development. The goal here is not necessarily to

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move toward path-breaking, advanced S&T-centric, and radical innovation, desirable though it may. Instead, it is to move toward sustainable and incremental innovation in the sense of introducing something new to a particular context, community, region, or nation (Nelson 2015).

Knowledge is a critical component of innovation and competitiveness at firm, farm, and national levels. It is therefore vital to create an environment that fosters the development, circulation and utilization of knowledge" through measures that include government policies in areas such as education, scientific research, and technology promotion (Kruss 2008; Albuquerque et al. 2015). A rethinking of the definitions and reconceptualizations of STI to include problem solving, indigenous knowledge through learning by doing, the development of innovation capabilities, and targeted STI policies is necessary. Related to this point on broadening the definition of STI, there is also a need to broaden the actors to include NGOs, advocacy groups, and civil society organizations, in addition to the major actors in sectors such as university, industry, and government.

In the sections that follow, I reexamine the connections between STI conceptualizations, relevance, and policy directions for Africa. I stress the importance of ensuring that STI in Africa is focused on problem solving (i.e., addressing development challenges). This is in line with Nelson's thinking: "Economic development in countries behind the technological frontier requires innovation both by firms, and by farms, hospitals, and other organizations that provide goods and services. This is not innovation in the sense of introducing something new to the world economy, but of introducing something new to the particular context" (Nelson, 2015, ix). In summarizing the arguments to define, rethink, and reconceptualize innovation in a way that is relevant to addressing societal needs and challenges, rather than innovation for innovation's sake, I revisit issues of definition, framing, and narratives. Here, I explain that the "Western" definitions of S&T and innovation were developed to suit the context, specific needs at that time, and practical realities of economic growth and competitiveness in advanced countries, driven by firms' productivity and performance (Freeman 1987). In this context and by these definitions, firms play the central role in innovation processes through R&D. As a result, there is nothing wrong with these definitions, for firms based in advanced countries (in the Global North). Nevertheless, the realization that innovation also occurs in nonfirm institutional settings leads to an expansion of these definitions and ensuing frameworks in order to ensure that they can help explain and promote innovation in the public sector, in services, and in other areas. This willingness to redefine, and to be open to redefining, is in itself innovation.

However, for Africa and the rest of the Global South, the situation is different in the sense that innovation activities from firms and formal institutions account for a significantly smaller amount of estimated national GDPs when compared with those of Global North countries. Therefore, the centrality of firms as users and producers of knowledge and STI in Africa (particularly in terms of products and services) is drastically diminished. This calls for rethinking the way innovation is conceptualized in Africa and the importance of ensuring

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that S&T, and innovation especially, adequately captures contributions from non-firm-based sources of innovation that arise in the informal economy in addition to formal R&D-driven, firm-based innovation.

The arguments therefore are (1) that various domains have contributed to the origins and development of STI studies, the implication being that Africans must be willing to engage with STI, to "experiment" (play with it), to foster innovation from a wide range of sources—anthropology, sociology, business and management, history, archeology, S&T, arts and media, and so on—and to conceptualize and constantly re/define STI if need be; and (2) that innovation is not necessarily based on formal institutions (firms), R&D, and basic science alone but can also result from informal institutions and settings and innovation practitioners with indigenous knowledge, not based on formal R&D and S&T. On the basis of these two propositions and preceding discussions, the meaning of STI from Africa must therefore shift from the current status of S&T- or R&D-based innovation from "laboratories" to a broader and more inclusive sense of innovation for development, in line with the needs, concrete realities, and aspirations of the continent.

Science, technology and innovation are major factors in the generation of economic and social change and can contribute to growth and development (Kraemer-Mbula and Wamae 2010). Although this notion is widely held to be true, experts in STI fields also acknowledge that innovation can lead to exclusion and inequalities in society (Cozzens and Kaplinsky 2009; Cozzens 2010; OECD 2012; Hart, Jacobs, and Mhula 2013; World Bank 2013). In South Africa, for example, Hart, Jacobs, and Mhula (2013, 3) maintain that "the continued presence of high levels of poverty, inequality and unemployment" has remained a major challenge. If the purpose of STI is to improve the quality of life, then perhaps STI reconceptualized in a way that broadens the concepts involved and enhances inclusiveness may contribute to ensuring that innovation addresses the needs of wider segments of society. This change in perception of STI is critical if it is to be relevant to both the rich and the poor in Africa.

Kruss (2008) describes an interesting knowledge production and circulation mechanism in which old and new forms of interactions coexist, resulting in partnerships among actors of innovation ecosystems aimed toward addressing societal needs. This involves complex systems that may be characterized by problem orientation, impact orientation, and policy orientation, with broad approaches that are inclusive rather than exclusive. A greater emphasis on the democratization of science by also including nonacademic stakeholders such as problem owners and policymakers in all stages of research, knowledge production, and problem setting should therefore stress mutual learning that includes traditional and local as well as scientific and expert knowledge. This balance is essential.

Measurement of Innovation in Africa

The *Oslo Manual* (OECD and Eurostat 2005) has remained the dominant guiding literature in the measurement of innovation according to indicators and surveys of R&D using the Community Innovation Survey (CIS) methodology (Daniels 2014). However, in spite of this global

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dominance, the *Oslo Manual* has been criticized for its inappropriateness for a Global South context (Salazar and Holbrook 2004; Schibany and Streicher 2008; Srinivas and Sutz 2008). Although the CIS-based innovation measurement approach captures innovation predominantly in the R&D realm and from formal sources, the approach is used widely around the world, including in Africa (AU-NEPAD 2010, 2014). Daniels (2014, 2) maintains that some of the weaknesses of the *Oslo Manual* that the CIS methodology does not address or measure, even though they are more relevant to Africa, include the use of R&D as a measure of innovation, definition and choice of measurement indicators, and confusion between measuring R&D and equating it with measuring innovation. Others include the importance of linking innovation measurements with economic development, productivity, and growth; an inability to sufficiently capture innovation from the informal sector, which accounts for a substantial amount of Africa's innovation activities; and the relationships between innovation and, for example, poverty, inequality, exclusion, and social progress.

The principal challenge lies in the indicators and measurement criteria used in identifying, mapping, and capturing some data while deciding what to prioritize, include, or exclude. Martin (2012b, 6–7) submits that a huge amount of "invisible"[10] innovative activity goes on in developing countries "beneath the radar"—for instance, incremental process innovations that do not involve R&D or work by "scientists" or patents, creating a case of "dark innovation."[11] This "dark innovation" in Africa needs to be defined, conceptualized, measured, analyzed, and better understood. There also is the risk of directionality[12] in innovation and the potential of being accused of "picking winners." A broadened, redefined, reconceptualized, or transformed notion of innovation in Africa, in line with the arguments advanced in this chapter, will help ensure that innovation from formal and informal sources are captured. The implication of such an approach is that the *Oslo Manual* and CIS, in their current forms, can no longer be central to innovation indicators or measurements in Africa.

Prior to STISA-2024, other initiatives, "plans," strategy documents, and policies[13] were designed with the same goal in mind: to use S&T and, more recently, innovation as mechanisms to drive socioeconomic development in Africa and emphasize the need for concerted efforts in this regard. Against the backdrop of these continental STI policies, decisions such as striving toward the investment of 1 percent of national GDP on R&D were born, promoted, and continue to be encouraged (STISA 2014, 40–41). Although well-intentioned, such passive policy directives as policy instruments have been difficult to justify in the political arena or to implement in national budgets. Two decades down the line, such blunt policy instruments have yielded less than optimum results. Also troubling is the implication for Africa's innovation ecosystem, which is still developing, and the underlying message that (formal) R&D equals innovation, thus undermining the support and promotion of non-R&D innovation sources that occur in the informal economy. At the country level, various STI policies and strategy documents—such as Kenya (Kenya2030 2013), Nigeria (FMST 2012), and South Africa's 2014 National Development Plan (NPC 2012)—reinforce this unflinching belief in formal STI as the panacea for Africa's development challenges.

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STI policies, like other public policies, exert considerable impact on development (Stiglitz 2012; UNDP 2014). Incumbent policies in a developing country context are particularly important in driving development projects, activities, and initiatives. In advanced countries, although an up-to-date innovation strategy is desirable and required to be incumbent, the innovation ecosystem is mature and robust enough for innovation activities to flourish, though sometimes at suboptimal levels, with minimum and predictable disruptions. This ability of innovation to flourish, even though sometimes at suboptimal levels, may be explained by the existence of strong formal institutions (Lundvall et al. 2009). In developing countries, however, the experience is somewhat different: Without the formulation and legitimization of an STI policy, for example, the relevant legal framework, funds, and resources may not be put in place. This partly explains some of the difficulties in operationalizing the AU's STISA-2024 plan or the directive to invest 1 percent of GDP into R&D. It also partly explains other weaknesses observed in STI policies across the continent.

Although STISA-2024 is a major step in the right direction, responses to the strategy have been insufficient and uncoordinated and may not provide the ideal level of constructive engagement that such a policy document with continental implications deserves (Marcelle, Daniels, and Whisgary 2014, 25). Another important insight that can be gleaned from Africa's policymaking is that policy learning is not taking place, or that the learning that has taken place has not been (or is not being) captured. As a dynamic innovation capability, learning involves experimentation designed to continuously improve organizational and policy performance (Teece, Pisano, and Shuen 1997; Eisenhardt and Martin 2000; Daniels, forthcoming).

Policy learning facilitates the strategic use of knowledge and information in policymaking, thereby inducing innovation (Bennett and Howlett 1992; Borrás 2011; Edquist 2011). Who learns, what they learn, and the effect of learning on subsequent policies are important factors in policymaking. Of the three interdependent levels of learning—government learning, drawing lessons, and social learning—the most relevant to this discussion is government learning, which relates to state officials learning about policy processes in policymaking and, by so doing, generating organizational innovation and change (Bennett and Howlett 1992; Borrás 2011; Daniels 2015).

In spite of general acknowledgment of the importance of policymaking to development and experience gained over the past five decades in Africa, evidence reveals that weaknesses[14] observed in extant policies, such as the Lagos Plan and CPA, are still evident in STISA-2024, which was formulated in 2014. Effective policy learning would help ensure that policies and policymaking exercises in the future adequately build on past knowledge and strengths while correcting for the weaknesses of extant policies and policymaking. As straightforward as these approaches may sound, conditions such as the availability of policy capabilities (individual and institutional), funding, and political will are necessary for success (Daniels 2015).

The challenge for Africa's STI stakeholder community[15] therefore is to identify and map the continent's STI and development ecosystems, determine and refine the continent's

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strategic priority areas, and conceptualize and transform these areas into policy priorities. This will require an in-depth understanding of policy capabilities (processes, routines, and skills; Daniels 2015), interactions among policy actors, and the government's extensive collaborative work with stakeholders.

Should Africa focus on mission-oriented STI policies, like sending astronauts to the moon, which generate less than 5 percent employment, or perhaps on agriculture (through innovation policies more relevant to grassroots efforts), which affects the livelihood of about 40 to 70 percent of the population involved in such sectors and accounts for about 50 percent of the employment in some countries? Or should it do both? Answers to such innovation policy and development questions are difficult and must be developed through robust policy engagements and interventions.

Policy learning, in conjunction with well-articulated policy research, is necessary for finding answers to such questions through various mechanisms. For example, it can help policymakers appreciate that the emphasis on mission-oriented, advanced R&D- and S&T-centric policies[16] (1) has produced less than optimum results; (2) has, as in other continents, contributed to inequality and social exclusion and exacerbated poverty in some cases; (3) has produced STI policies and policymaking exercises driven by governments (and neglecting industry, academia, and civil society), based on the use of "experts" and societal elites, without active participation of the poor and marginalized, contributing to the weaknesses observed in policy learning, increased policy somersaults, and resulted in policy failures; and (4) provides justification for a change to a balanced policymaking that incorporates STI policy instruments that foster inclusive development and respond to innovation initiatives at grassroots levels.

Conclusion

An understanding of STI in Africa informs the meaning of STI *from* Africa, the conceptualizations and definitions of STI, knowledge generated and captured, and the relevance of STI to citizens. In addition, these attributes determine what is measured (or not measured), the policies formulated to support and promote STI, and the enabling environments for STI created in the continent.

What does STI mean from Africa? Drawing from the analysis of this chapter, the answer lies in neither advanced R&D- and S&T-centric innovation on the one hand nor grassroots innovation on the other hand. It lies in both. If innovation is meant for development (OECD 2012; UNCTAD 2014), the most important criteria for measuring its impact and effectiveness in Africa must be based on carefully selected, context-specific development indicators that value and incorporate as examples the number of jobs generated, poverty reduction metrics/proxies, reductions in inequality and the social interactions such reductions enable, and so on. Such a system would acknowledge that indicators such as patents, number of publications, citations, and researchers, although equally critical to innovation and development,

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cannot and should not be used in isolation as the only valid metrics, as is currently the case in many AU establishments and related agencies.

Although the critical mass of STI scholars and policy practitioners may be less than what is desired, Africans skilled in STI areas are based in practically every world-class research, policy, or government institution across the globe. The elephant in the room therefore is this: What is stopping the continent from redefining, reconceptualizing, theorizing, applying, and utilizing STI in a way that suits Africa's specific contexts and realities? Is it a case of waiting for endorsements from its Global North counterparts and colleagues? There is absolutely no need for that! The development challenges to tackle are too grave to allow for any form of complacency or delays in taking the necessary steps needed to harness the potentials of STI, like other nations and continents, and refocus the continent's economies and development trajectories.

If STI is defined, conceptualized, and understood as a mechanism that is, for example, useful in converting African history, stories and folklores, crafts, culture and traditions, and so on into world-class arts, music, movies, cartoons (printed, computer, and TV-based), apps, books, merchandise (clothes, toys, accessories), resulting in some form of Silicon Valley–styled network of actors, businesses, incubators, and venture capitalists and creating millions of jobs (e.g., computer graphics work, designers, programmers, marketers, distributors), then STI may take on a different conceptual meaning, value, and relevance. This change can help diffuse the tension between "mission-oriented" and "grassroots" innovation policies and contribute toward a balanced innovation policy approach that strives to increase national innovation capabilities, inclusive growth, and sustainable development while reducing poverty levels, inequality, and exclusion of all forms and at all levels.

State of Science and Technology in Africa

- Africa, the poorest continent has also the weakest research infrastructure
- Africa produces less than 2% of the World research publications referenced by citation indexes [India [2.5%) and Latin America 3.5%]
- Lack of research capabilities and continued brain drain
- South Africa and Egypt produce 50% of the Continent's publications
- Disciplinary analysis reveals that few African countries have the minimum number of scientists required for the functioning of a scientific discipline
- Africa's inventive profile (Patents): less than on thousand of the World's inventions
- 88% of the Continent's inventive activity is concentrated in South Africa
- The GERD objective of 1% GDP has not yet been reached by the vast majority of African countries

Figure 9.2
Impact of measurement indicators on STI definition, interpretation, and conceptualization in Africa.
Source: Vroh 2014.

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Notes

1. The New Partnership for Africa's Development (NEPAD), a strategic framework for Pan-African socio-economic development, is both a vision and a policy framework for Africa in the twenty-first century. NEPAD is a radically new intervention, spearheaded by African leaders, to address critical challenges facing the continent: poverty, development, and Africa's marginalization internationally.

2. Such as development, economic, finance, environmental, and other policies directly and/or indirectly connected to STI policies.

3. Such as piped water, sanitation, electricity, and refuse removal.

4. For a comprehensive review and more in-depth study of the literature, see, for example, Godin (2008a, 2010a, 2010b) for genealogical history and Martin (2012a) for recent accounts.

5. Science Policy Research Unit (SPRU), University of Sussex, United Kingdom. Chris Freeman was the founding director of SPRU.

6. Used in this instance as a synonym for developing and/or less developed countries.

7. See, for example, UN (2004, 2013); World Bank (2004); AFDB (2012); The Economist (2014); and UNICEF (2014).

8. Opportunities that open up for a country as result of effective management of demographic transitions.

9. Or a third, sometimes distant relative, public policy courses—although the majority of the courses in this third group do not target STI.

10. Because it is generally not captured in conventional innovation indicators.

11. Martin (2012b) borrows an analogy from astronomy, in which telescopes reveal only a small proportion of the universe; the majority lies unseen in the form of dark matter and dark energy. Even though we know it is there, we cannot measure it, at least not directly with our existing instruments—analogous to innovation occurring in Africa's informal economy.

12. In this sense, referring to who decides what is important and what is not.

13. For example, the Monrovia Strategy of 1979, the Lagos Plan of Action (LPA 1980), the Consolidated Plan of Action (CPA 2005), and now STISA-2024 (STISA 2014).

14. Such as a lack of commitment and funding from national governments, a top-down government approach, insufficient stakeholder engagement, and so on.

15. Government, academia, industry, civil society and rural communities, and others.

16. Made over the last three to five decades (and more recently, innovation policies in some countries).

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Contributors

Geri Augusto is visiting associate professor of Africana studies at the Institute at Brown for Environment and Society, Brown University.

Shadreck Chirikure is an associate professor in the Department of Archaeology at the University of Cape Town.

Chux Daniels is a teaching fellow in innovation studies in the Science Policy Research Unit at the University of Sussex.

Ron Eglash is a professor in the Department of Science and Technology Studies at Rensselaer Polytechnic Institute.

Ellen K. Foster is a doctoral student in the Department of Science and Technology Studies at Rensselaer Polytechnic Institute.

Garrick E. Louis is an associate professor in the Department of Systems and Information Engineering at the University of Virginia and the director of the University of Virginia Center for Small Infrastructure and Development.

D. A. Masolo is a professor of philosophy and a distinguished university scholar at the University of Louisville.

Clapperton Chakanetsa Mavhunga is an associate professor of science, technology, and society at the Massachusetts Institute of Technology.

Neda Nazemi is a process engineer and holds a master of science degree from Tarbiat Modares University.

Toluwalogo Odumosu is an assistant professor of science, technology, and society and of electrical and computer engineering at the University of Virginia.

Katrien Pype is a research professor with the Institute for Anthropological Research in Africa at KU Leven University and a Birmingham fellow at the Department of African Studies and Anthropology at the University of Birmingham.

Scott Remer earned his PhD in philosophy from the University of Virginia and is a consulting analyst at Hexagon Energy.

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Index

3-D, 25, 130

Aakash Ganga, 163, 166, 167
Abbas, 133
Academy, the, 63–65, 73
Accountability, 26, 162
Accra, 21, 25, 128, 130–132
Actor network, 106
Aesthetic, 32, 80, 82, 91–92, 101
Africa in STS, ix, 79
African, ix–2, 5–7, 9–27, 29, 32, 35–37, 42–44, 46–47, 49, 57, 60, 61, 63–67, 69–77, 79–83, 85–95, 97, 99–101, 103–104, 109–114, 117–118, 121–124, 127–130, 133–135, 137–141, 143, 145, 147–152, 154, 157, 160–163, 166–167, 169–171, 176–178, 180, 184–185
Africana, xiii, 80, 87, 93–94
African biochemical warfare, 60
African biology, 60
African chemistry, 60
African Development Bank, 157, 161
African invention, 67, 86
African reinvention, 86
African socialism, xi, 17-18, 117, 134
African technology, xi, 36, 71, 73
African Union, xiv, 1, 27, 169
Africanzone, 20
Afrigadget, 128
Afrofuturism, 1
Agbobloshie, 133
AMCOST (African Ministerial Council on Science and Technology), 27, 169
Amerindians, 93
Ananse, 122
Ancient Egypt, 39, 41, 44
Animateurs, 105
Apartheid, 5, 128
Appiah, 131, 132
Apple, 46, 63, 111, 137
Apprentice, apprenticeship, xi, 10, 11–12, 18, 76, 104, 177–178
Appropriating, 25, 111, 196
Appropriation, 25, 88, 102, 139–140, 148–149, 189, 196, 202, 213
Architecture, architectural, 3, 41, 75, 91, 121, 123, 148, 150
Architectural tradition, 121
Archive, archival, x–xi, 22, 46, 80, 92, 104
Arduino, 124–126, 131, 133
Arochukwu, 12
Artifact, 2, 4–5, 7–8, 26, 38, 41, 60, 83, 88, 128, 138, 139–140, 149, 151–152, 154
Asia, 64, 83, 153, 153, 164
Assemblage, 25, 72, 80, 83, 86–88, 91, 93, 94, 105
Assembly, 47, 86, 89, 91
Astronomy, 3, 37–38, 152, 185
Asymmetrical warfare, 61

Bag bellow, 68–69
Baidoo, 130
Ba-ila, 121, 123

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Bakatwa, 51
Basic needs, 27, 154, 156–157
Baule, 118–120, 125
Bay-Dole Act, 59
Bench science, xii, 9, 60
Benin, 21, 6121–122, 163
BHCA, 146–148
Biological warfare, 47
Biological weapons, 52
Bira, 51
Biri, 50
Blacksmith, 102–106, 114–115, 133
Bloomery process, 65
Bogota Manual, 27
Bonfire, 52
Bongo, 108–109
Bot Club, 131
Botswana, 19
Botswana Innovation Hub, 19
Bottom-up, 121, 124, 127, 130–131, 134
Bowl furnace, 66–67, 76
Brazil, 19, 80, 83, 94–95, 121
Bricolage, 128, 132
Bricoleur, 105
BSC, 144–146
BTS, 144–145
Built environment, 63–64, 86, 130
Burkina Faso, 21, 163
Burundi, 163
Buya tinapangana, 16

Cabinet, 83–85
Cairo, 99, 113
Call setup, 145, 147
Call setup procedure, 145
Cameroon, 74, 163
Candomble, 95
Capability, 25–26, 107, 138, 156–158, 164, 166–167, 182
Capacity building, 152, 152, 157–158, 161–162
Capitalism, 17, 59, 63, 73–74, 117, 123–125, 134
Capitalist entrepreneurship, 13
Capricious, 102–103, 106–107
Carried knowledge, 24
CDMA, 138, 141–144
Cell phone, 18, 25, 36, 129, 137–139, 143
Central African Republic, 163
Central Market, 102
Certifiable knowledge, 3
Chad, 14, 163
Chainga, 72
Chaminuka, 49–50
Chaos Computer Conference, 127
Chapungu, 50–51
Charisma, 107–108
Charpie Report, 9
Chasura, 50
Chemical, 23, 37, 43–44, 52, 70, 134, 139
chiMurenga, 45
Chicotte, 13
Chidembo, 55
Chidzimbahwe, 46, 52, 55, 58–59, 61
Chidzivachepo, 48
Chihunduro, 56
Chikudyu, 53
Chimurenga, 23, 45–47, 50–52, 58, 60–61
Chinese, 3, 59, 74
Chinyavada, 57
Chipotanemadziro, 56, 60
Chirwirangwe, 55
Chitsinga, 57
Chiva, 56
Chivi, 50
Chokwadi, 59, 61
Christian, 15, 39, 108
Circulation, 117, 123, 126, 135, 178–180
CLTS, 163, 166
Co-constitution, co-construction, 138
CoCreation, 131
Code, 7, 38, 52, 111, 121, 124–126, 130, 143
Cold Storage Commission, 17
Colobane, 25, 128–129
Colonial, ix–xiii, 2, 5–7, 11–18, 22–24, 45, 47, 52, 59, 61, 64–65, 67–71, 74–77, 80, 91, 93, 100, 104, 107, 113, 119, 123–124, 128, 134, 151–152

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Colonialism, 5, 11, 13, 16, 24, 59, 64, 76, 80, 91, 123, 128, 151
Colony, colonies, 16, 22, 64, 79–81, 84, 91
Commerçants, 111
Commercialized innovation, 9
Commons, 26, 45, 124, 126
Communal 16, 18, 23, 30, 34, 43, 47, 51–52, 55, 58–59, 61, 73, 76–77, 123–124, 127
Communalism, 58
Communication signal, 52
Communicative ecology, 139, 143
Community, 1, 12, 15, 32–36, 43, 46–47, 49, 52, 55–56, 59, 61–62, 76, 115, 124, 126, 129–130, 133, 139, 151, 157, 163–166, 179–180, 182
Community-driven knowledge-sharing practices, 133
Community innovation survey, 180
Community security, 52, 56
Comoros, 163
Competitive strategy, 172
Computer programming, 130–131
Cone Textiles, 17
Congo, 13, 20, 24, 48, 50, 67, 88, 97, 99–101, 103, 106–107, 109–112, 115
Congo River, 111
Congo-Brazzaville, 109
Congolese, 100–101, 106–107, 110–112, 115
Constituting, 25, 139
Constitutive appropriation, 25, 139–140, 148
Constitutive, 25, 46, 108, 139, 139, 139–140, 142, 148
Consume, consumer, consumption, 1, 4, 8, 22, 108, 125–127, 139–140, 147–148, 158
Context-specific innovation, 65
Copper, 65, 68, 76, 132, 142–144
Cosmogonic, 40
Cosmogram, 86, 88
CPA, 169, 182, 185
Craft, 3, 70, 73, 104, 126, 128
Create, 13, 17, 19, 34, 48, 56, 61, 68, 74, 80, 82–83, 87–88, 91–93, 101, 104, 108, 110, 117, 121, 123, 129–134, 154, 162, 176–179, 183
Creating, ix, 13, 19, 21, 24–25, 46, 59, 68, 72, 91, 99, 102, 111, 121, 123, 130–132, 139, 156, 181, 184
Creation, 18, 26, 37, 39, 49, 59, 61, 80–81, 101, 108, 131, 133, 139, 139, 151, 154, 169–170, 176
Creative resilience, 13–14
Creativity, 2, 5–6, 8, 10, 13–14, 23–25, 43, 45, 47, 60, 79–82, 91, 94, 97–99, 102, 108–110, 112–114, 119, 128–133, 149, 154–155, 177
Creativity Group, 128, 131–133
Credit, 3, 13, 15–16, 19, 21, 141
Cuba, 19, 29, 59, 129, 184
Curiosities, 85

Dairy Marketing Board, 17
Dar es Salaam, 108, 109
DARPA, 127
Darryn Textiles, 17
Dáti, 51
David Whitehead, 17
Decolonial, 6, 209
Decolonize, xi
Decolonizing, 22, 77
Decolonizing the mind, 22
Definitional power, 1
Demo, 51
Denationalization, 17
Dépaysement, 29
Dependency, 160–162
Deregulation, 17
Design, xii, 4, 7, 10, 21, 24, 26, 31, 33–34, 39, 42, 69, 72–74, 80, 107, 121, 138–139, 141–142, 146–150, 157, 165, 178, 181–182, 184
Development, ix, xiv, 6, 9, 19–21, 26–27, 35–36, 43, 63, 65, 67, 95, 110–111, 114, 129–131, 133–134, 142, 148–149, 151–167, 169–185
Dhibhura, 51
Dhow, 14–15
Diaspora, xi, xiv, 20–21, 79, 81, 87, 89, 94, 122
Dikenga dia Kongo, 86
Dimensioning, 26, 146–150

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Dimuro, 51
Directionality, 4, 15, 82, 94, 172–173, 181
Disease, 5, 24, 40, 42, 154, 170
Disinterest, 3, 58
Dissect, 58
Distributive justice, 117, 134
Divination, 103, 105–106
Diziro, 52
Djibouti, 163
Docteur, 107, 115
Dogon, 122
Domain, 30, 38, 49–50, 70, 72, 103, 105, 124–125, 172–173, 180
Domestic artisanry, 29
Domestication, 140
Doxa, 22
Dzimba dzemabwe, 45
Dzimbahwe, 23, 45–50, 52–62
Dzinza, 49
Dzvinyu, 56

Ecology, 5, 42, 139, 143
Ecosystem, 118, 170, 180–182
Education, 11–12, 18, 43, 52, 59, 97, 99–100, 127, 130–133, 137, 153–157, 159, 170, 172, 175, 177–179
Egalitarian, 33, 117, 121, 123, 134–135
Egyptian, 3, 23, 36–41, 44
Electricity, 4, 100–104, 107, 155, 158–159, 166, 185
Elikya, 111
Emic, 97, 103
Encounter, xii, 16, 30, 35, 55–56, 58–60, 81, 99, 148
Endogenous, ix, 9, 15, 34, 36
Energy, 7, 24, 100–101, 103, 127, 155–156, 158–159, 163, 166, 170, 185
Engineer, engineering, x, xiii, 4, 11, 18, 26, 101, 104–107, 113–114, 118, 121, 132, 138, 141, 144, 146–150, 177
Enslaved African, 24, 79–83, 85, 89–90, 92–93
Entrepreneur, x, 9–19, 99, 107–110, 130–131, 170–171, 177–178
Entrepreneurship, x, 9–11, 13, 15–19, 170–171, 177
Environment, xiv, 4, 6, 8, 11, 22, 29, 40–43, 63–64, 67, 74, 79–83, 86, 91–93, 108, 113, 117–118, 121, 123–124, 130, 132–134, 154, 158–159, 163, 165, 170, 174–175, 179, 183, 185
Epistemic walk, 80, 94
Equipment, 12, 52, 63, 68, 73, 104–106, 113, 131, 144, 148–149
Ericsson, 148, 150
Eshu, 122
eSoko, 21
Essential human services, 152, 154, 156, 158, 167
Ethiopian, 118
Ethnophilosophy, 29–30
Europe, ix, 2, 4–8, 10–17, 19, 23, 25, 27, 29, 53, 59, 63–65, 67, 69, 71, 73–75, 77, 79, 81, 83–85, 90, 92, 104, 110, 117, 123–128, 144, 146–147, 152, 165
Everyday life, xii, 25, 138
Evisceration, 40
Experience, xii, 5–6, 24, 26, 54–55, 58–61, 71, 80–82, 89, 93, 98, 101, 105, 111, 114, 138, 140, 144, 161–162, 165, 174–175, 182
Experiment, 3, 5, 10, 15, 23–24, 58, 61, 63–65, 67–70, 72–73, 75–77, 97, 131, 180, 182
Expert, 3–4, 7, 9, 12, 22, 43–44, 81, 95, 97, 102, 104–110, 113–114, 121, 130, 133, 38, 162, 164, 180, 183
Extract, 7, 12, 15, 22, 44, 56–57, 60, 87, 117–118, 124, 126, 132, 134, 165
Eyison, Josiah, 130–131

Facebook, 20–21, 109–110, 112, 115
Factory, 16, 38, 124–126, 134
Facts, 1, 58, 61, 65, 73, 97
Falsifiability, 3
Famine, 55, 118
Femhack, 127
Féticheur, 108
Fixed, 12, 16, 18, 24, 64, 134, 143–144
Fixer, 25, 127–129, 132

Downloaded from http://direct.mit.edu/books/book-pdf/2105138/book_9780262342322.pdf by guest on 06 August 2023

Fixers Collective, 127, 132
Flashing, 147–148
Flies, 57
Fly, 50, 55, 83, 94, 160
Food, 17–18, 41, 48, 52–54, 72, 80, 85, 91–93, 124, 155, 159, 162, 170
Food-for-work, 18
Foreign, 4, 11–12, 14, 16, 26, 30, 32, 35–36, 50, 114, 157, 160–162, 167
Foreign aid, 26, 160–162, 167
Forest, 10, 12, 23–24, 46, 48–49, 52, 55, 81, 197
Formal network, 178
Forms, xi, 5, 10–11, 13, 18, 20–21, 26, 29–30, 42, 59, 63, 93, 97–98, 103, 108–110, 112–114, 117–118, 121, 123–124, 126–127, 132, 134–135, 141, 151–152, 160, 160–161, 180–181, 183–184
Fractal, xiii, 121–123, 129
Fractal architecture, 123
Frascati Manual, 27
Freedom, 7, 27, 43, 47, 81–82, 93, 95, 138, 167
Furnace, 10, 24, 65–69, 72, 74–76

Gambia, 163
Gano, 51
Garamba, 109
Garden of Eden, 39, 123
Gardens, 2, 80–81, 83–88, 91–93, 167
Garingiro, 52, 54
Gather, x, 115, 129
Gatherer, 123
Gathering, 2, 32, 59
GDP, 157, 161, 172–173, 179, 181–182, 184
Gender, 7, 35, 73, 75, 101, 112, 123, 127, 154, 158–159
Genealogy, 47–48, 79–80, 83, 88, 93–94, 185
Generative intersection, 79
Generative justice, 117, 119, 121, 123–125, 127, 129–135
Generative waste, 132
German, 11, 110
Ghana, 19, 21, 25, 114, 121–122, 128–131, 133, 137, 163
Giyani, 71
Global North, 7, 100, 113, 179, 184
Global South, 4–5, 23, 99–100, 172, 177–179, 181
Global Water Operators Partnerships Alliance, 164
God, 23, 25, 39, 41, 45, 48–49, 108, 121, 129
Gokomere, 48, 72
Gona rezhou, 49
Google, 73
Góorgóorlus, 129
Government, 9, 11, 14–15, 17–18, 35–36, 43, 99–101, 109, 111, 117, 130–131, 134, 151, 154, 156, 160, 162–166, 178–179, 182–185
Grain Marketing Board, 18
Grassroots, 14, 127, 132, 171–173, 176–177, 183–184
Great Zimbabwe, 45, 48, 50, 67, 76, 152
GSM, 138, 141–145, 148
Gudo, 57
Guinea Bissau, 163
Guinea, 58, 73, 76–77, 163
Gunguwo, 49–50
Guruhuswa, 47–48, 50
Gurwe, 53–54

Hackathon, 131
Hacker, 124, 127–129, 133
Hackerspace, 25, 127, 130
Hadyana, 72
Hardware, 99, 124–126, 131, 138, 143, 148, 150, 165
Haya, 151
Healthcare, 18, 99, 155–156
High-shaft natural draft furnace, 66
Hilltop, 52
Hitler, 58
HLR, 144–145
Hodzeko, 72
Home phone, 143
Homestead, 24, 52, 69–70, 73–76
Homesteads as laboratories, 70
Hondo, 55
Hondo yekuzvisunungura, 46

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Hovhoni, 18
Hub, 11–12, 19, 102, 110, 129–131, 133, 144
Huhwa, 51
Human potential, 154, 156
Human resources, 156–158, 162–164
Humbu, 100
Hunger, 154, 158–159
Hungwe, 50
Hunhu, 47
Hunt, 8, 10–12, 44, 49–51, 54, 58–59, 109, 123, 152
Hunter, 54, 109, 123
Hunting, 10–11, 44, 49–51, 59, 123, 152
Hurimbo, 56
Hwedza, 57
Hxaro, 123

ICIPE, 42–43
iCow, 21
ICT, 18–21, 111–112
Identity, 22, 34–35, 91–92, 144,
Idiom, 7, 15, 30, 36, 103–105, 113
Imagine, imagination, imagining, 2, 6, 22, 32, 34, 36–41, 44, 79–80, 82–83, 86, 91, 93, 95, 99–101, 107, 110, 112, 121, 134, 139, 150, 175
Imba yebwe, 45
IMF, 9, 17–18, 20, 196
Imitation, 8, 18, 38, 76, 92, 104, 108, 112
Immortality, 38–39
Immortal nourishment, 40
Important, 1, 11, 19, 23, 27, 29, 34–36, 49, 64–65, 70, 73, 76, 83, 90, 92, 97, 99–100, 105, 114, 138–139, 144–148, 150, 157, 163–164, 172–174, 178, 182–183, 185
Important knowledge, 23, 29, 65
Imported magic, 6
Imports, 13, 17
Improvement, 4, 175, 178
Inbound, ix–x, 7, 9–10, 13, 15, 18–19, 21
Inbound thing, ix, 7, 15
Incidental innovation, 151–152
Inclusion, 164
Inclusive, 131, 164, 171–176, 178, 180, 183–184
Inclusive development, 176, 178, 183
Inclusive innovation, 171, 176
Inclusive innovation, 171, 176
India, 2, 19, 58, 70, 109, 164, 166, 184
Indian entrepreneurship, 16
Indicator, xiv, 8, 37, 76, 152–154, 170, 172, 175–177, 180–181, 183–185
Indigenous, xiii, 13, 17, 19, 22–25, 27, 29–31, 43, 46, 48, 57, 59, 64–66, 69–70, 73, 75–76, 79–82, 84, 88, 94–95, 103, 114, 117–118, 124–125, 129, 134–135, 149, 152, 172–174, 177, 179–180
Indigenous American, 57
Indigenous knowledge, xiii, 19, 22–23, 27, 30–31, 59, 73, 84, 88, 94, 114, 172–174, 177, 179–180
Indigenous knowledge system, 19, 22–23, 30, 88, 94
Industrial, 4, 6, 8–9, 16–18, 27, 43, 65, 74–76, 100–101, 109, 117, 128, 149, 152, 160, 173, 179, 183, 185
Industrial revolution, 4, 8, 74
Informal networks, 178
Informal sector, 12, 132, 177, 181, 202
Informal, 10, 12, 16, 23, 27, 108–109, 113, 129, 132, 172–175, 177–178, 180–181, 185
Informalization, 23
Informalized, 10, 16, 27
Informant, 6, 22
Information and communication technology, 9, 11–12, 18, 21, 35, 58, 63, 72, 75–76, 100, 105, 111, 114, 125–126, 130, 144–145, 148, 175, 182
Information economy, 9
Information technology, 63, 125–126, 130
Infrastructure, 19, 23, 26, 46, 52, 73, 99–100, 105, 107, 110, 113, 137, 142–144, 149, 154, 157, 161, 164, 166, 170, 184
Infrastructure development, 19, 157, 170
Innovation, ix–xi, xiii–xiv, 1–2, 6–13, 15–16, 18–19, 21–27, 30, 34–36, 41–42, 45, 47, 49, 51, 53, 55, 57–61, 64–68, 70, 72, 74–77, 79–83,

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87, 89, 91–94, 97–101, 107–108, 112–114, 121–125, 127–131, 133, 138, 151–163, 165, 167, 169–185
Innovation for development, 7, 26, 151–159, 161–163, 165, 167, 180
Innovation ecosystem, 170, 180–182
Innovation policy, xiii–xiv, 175, 183
Innovation strategy, xiv, 1, 26, 169, 182
Innovator, 8, 22, 24, 60, 76, 97, 101, 108, 130, 171
Insect, 16, 42–43, 51, 53, 57–58, 61
Institutional innovation, 151, 158
Intel, 127, 129
Intellect, ix–xii, 3, 5–8, 22–23, 27, 36–37, 59–60, 92–94, 108, 113, 124, 170–171
Intellectual, ix–xii, 3, 6–7, 22–23, 36–37, 59–60, 92–94, 108, 113, 124, 170–171
Intellectual history of technology, 7
Intellectual property, 3, 113, 124
Internationalization, 42
Internship, 25, 129
Invention, 4, 8, 36, 64, 67, 81–82, 86, 89, 93–94, 101–102, 111, 114, 151
Inventiveness, 24, 91
Investment, 11, 73, 117, 156–157, 160–161, 176, 181
Investor, 17
iRoking, 20
Irregular rearrangement, 91
Islamic, 2, 39, 76, 128
iSpace, 25, 130–131, 135

Jamaica, 84, 91, 95, 138–139
Japanese, 57, 137, 149
Jewish entrepreneurship, 16
Joshua, Tomitope, 20
Jula, 11–12

Kabeya, Filip, 110–111
Kabila, Joseph, 100
Kaguvi, 49
Kalunga, 82
Kame, 48
Keitai, 137, 149
Kenya, xii–xiii, 14, 16, 19–21, 27, 31–33, 36–36, 42–44, 58, 115, 137, 163–165, 173, 181
Khartoum, 112, 219
Kinois, 24–25, 97–101, 103, 106–110, 112–113
Kinshasa, 24, 97–102, 106–110, 112–114, 194–195
Knowing, xi, 1–2, 8, 10, 57, 61, 63–65, 76–77, 100, 106, 109, 127
Knowledge-based economy, 9
Knowledges, 2, 4, 24, 77, 79–80, 82, 94–95, 127, 130, 132
KNUST, 131–132
Kolwa, 15–16
Kosikola, 24, 97–98, 114
Koyeba, 24, 98
Kozala na mayele, 24, 98
K-Rep Bank, 165
Kubata vamwe vanhu semhuka, 59
Kuchera mbeva, 52
Kudzamisa pfungwa, 60
Kudzura, 75
Kufamba nemaitiro emhuka, 60
Kufudza mombe, 56
Kufukidza, 51
Kugadzira, 46
Kuhuni, 59
Kulea, 123
Kumasi, 128, 131–132
Kunda, 25
Kunzvera, 61
Kurovera, 75
Kusika, 46, 60
Kutora mhuka sevanhu, 59
Kutsindira, 52
Kuva, 110–111
Kuvhima, 59

Laboratories, xii, 24, 63–65, 69–70, 72–75, 77, 107, 180
Laboratories without buildings, 24, 65
Laboratory, xii, 3–5, 8, 23–24, 46–47, 52, 58, 60–61, 63–65, 67, 69, 71, 73–77

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Lagos, 25, 130, 140, 142, 150, 182, 185
Lake Natron, 37, 44
Lamu, 14–15, 194
Landline, 141–144
Language, x–xii, 2, 4–5, 12, 22, 24, 45–47, 54–55, 58, 77, 97–98, 108, 110, 141, 143, 149
Las Gidi, 20
Latin America, 5, 19, 27, 64, 80, 153, 184
Lebanese entrepreneurs, 16
Legba, 121–122
LEGO Mindstorms, 131
Lesotho, 161
Liberating Ourselves Locally, 127
Liberation, 22, 46, 79, 81–83, 85–89, 91, 93, 95
Liberation flora, 79, 81–83, 85–89, 91, 93, 95
Life, xii, 12, 20, 25, 32, 38–43, 48–50, 59–62, 81–83, 85, 92, 98–99, 101–102, 105–108, 110, 112, 118–122, 127, 138, 140, 142, 165, 174–175, 178, 180
Lihau, 101
Limbo plants, 79, 81–83, 85–87, 89, 91, 93, 95
Lingala, 24, 97–99, 104
LinkedIn, 20,
Lion spear, 31, 33
Local knowledge, 64
Lukasa, 88–90

Maasai, 23, 31–36, 43, 104
Machine, 4, 8, 11, 13, 15, 21, 114, 132
Madagascar, 21, 163
Mago, 57
Magutsa, 55
Mahewu, 72
Maitiro, 60
Maji Ni Maisha, 163, 165
MakerBots, 133
Maker community, 7, 117
Maker magazine, 128
Maker movement, 117, 124, 127, 129, 133, 135
Makerspace, 25, 127–130, 132–133, 135
Makgadikgadi, 123
Making, ix, xi, 5, 8, 10–11, 13, 19, 24, 29, 34, 36, 38, 40, 46, 51, 60, 64, 68–75, 80, 83, 93–94, 109–111, 121, 127–129, 133, 137, 139–141, 143–147, 149–151, 154, 164, 173, 177, 182–183
Making do, 128–129
Makona, 49
Makurwe, *gurwe*, 53–54
Malawi, 21, 53, 63, 67, 74, 163
Mali, 70, 122, 160, 163
Mambuze-mbuze, 52
Mandela, 19, 101
Mankou, 111
Manyatta, 34–35
Manyusa, 48
Mapani, 52
Mapungubwe, 48
Marishe, 52
Market, 9, 12–13, 16, 21, 25, 33, 40, 67, 85, 99, 101–102, 104, 106, 117, 124, 128, 134, 144, 147, 149, 160, 175
Market economy, 117
Marketplace, 11–12, 16, 36, 102, 132, 143, 166
Maroon, 80, 82–83, 91, 93
Mashoko, 58
Masimba, 48
Masvingo, 50
Mathematics, 3, 152, 177
Mauritania, 163
Mayele, 24–25, 98–99, 109, 111–114
Mbada, 55
Mbadzo, 51
Mbeki, 19
Mbende, 53
Mbeva, 52–54
Mbiya, 72
Mbonga, 49–50, 61–62
Mbudo, 52–54
Mbuji Mayi, 105
Mbuyamuderere, 50–51
MDG, 26, 152–153, 158–159

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Mdundo, 20
Mean from Africa, ix, 1, 170, 183
Meaning, ix, xi–xii, 1–2, 4, 7, 27, 30–31, 37–38, 43, 45, 50, 58, 60–61, 82–83, 85, 87–88, 97–98, 102, 108, 111–114, 123, 139, 141–143, 172, 175, 177–178, 180, 183–184
Measure, measuring, measurement, 2–5, 8–9, 27, 32, 42, 61, 69, 106, 146–147, 170–172, 175, 177, 179–181, 183–185
Mechanic arts, 3
Mechanical discovery, 4
Medicine, xii–xiii, 3, 17, 49, 56, 79, 92, 104, 130, 152, 162, 178
Mensa, 131–132
Meroe, 69
Mgbere ngwere, 12
Mhando, 60
Mhani, 50, 57
Mhenenguro, 58
Mhizha, 51
Mhondoro, 48–51
MHT, 146–147
Mhungu, 56
Microsoft, 127, 129
Mkito, 20
Mobile, 11–12, 18–19, 25–26, 81–82, 93, 101, 111, 137–150, 173
Mobile line, 141
Mobile phone, 19, 21, 25, 101–103, 105, 111, 114, 137–150
Mobile switching centers, 144
Mobile technology, 11, 18, 19, 25, 150
Mobile telephony, 137–138, 144–145, 149
Mobility, xiii, 1–2, 4, 48, 51, 82, 94, 99, 112, 114, 142, 144, 170
Modern, 1–3, 17, 22, 30, 36, 39–40, 43, 63–64, 69, 72, 74–77, 94–95, 100, 107, 113–114, 121, 123, 137, 169
Modernism, 121
Modernity, 1–2, 30, 43, 137
Mohammed, 39
Montreal, 127
Mosquito, 42, 57
Movement, xi, 6, 16, 18, 21, 40, 48, 50, 54, 91, 102–103, 117–118, 124, 127, 129, 133–135
Moving, 12, 16, 70, 76, 107, 124, 132, 141, 162
Mozambique, 14, 16–17, 21, 57, 76
M-Pesa, 27, 36, 173
MSC, 144–145, 147–148
M-Shamba, 21
Msimang, 15
MTN, 146–148, 150
Mubhadha, 51
Muchembere, 50–51
Muchetura, 51, 56
Mudzimu, 48
Mukana, 50
Mukonde, 56
Mukwati, 49
Muleta Pamba, 14, 17
Multicultural knowledge production, 2
Mupawose, 48
Mupfuhwira, 56
Mupumhi, 49
Murenga, 23, 45, 48, 50, 60–61
Muridzi wapasi, 57
Museve, 51
Mushandirapamwe, 51, 55
Muslim, 2, 36, 39, 39, 112
Mutangakugara, 48
Mutapa, 48
Muteyo, 51
Mutimwi, 66
Muzongozozo, 60
Mvaisi, 51
Mvoti, 15
Mwari, 23, 45, 48–50
Mwena, 52–54, 56
Mwenda, 50
Mwenezi, 57
Mwoyo, 60
Mxit, 20
Mystical, 102–103, 106–109
Mystique, 98–99, 103, 108–109
Mziiki, 20

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National development, 26, 133, 156, 158, 161, 181
National system of innovation, 9, 171, 174
Native, 5–6, 16, 22, 39, 46, 49, 54, 70, 80, 83, 85, 91, 97, 98, 99, 130, 163, 176–177
Natron, 37, 40, 44
Natural, 2–3, 9, 19, 23–24, 39–41, 44, 64, 66–68, 79, 84, 86, 95, 104, 117–118, 126, 128, 141, 147, 156, 158, 165
Natural philosophers, 3
Natural philosophy, 2
Nature, xi, xiii, 6, 14, 25, 29–30, 34, 38, 42, 44, 50, 64, 69, 73, 83, 118, 124, 126, 132, 134, 139–140, 173, 177, 178
Nazis, 58
Nigeria Communications Commission, (NCC) 146
Ndebele, 52, 56
Ndoki, 25, 103–104
Ndororo, 53
Ndufu, 55
Necessity, ix, 41, 82, 107, 127–128, 130
Negative portrait of Africa, 24
Negritude, xi
Nehanda, 49
Neo-colonial, 22
NEPAD, 157, 169, 181, 185
Net neutrality, 130, 209
Network, 20–21, 26, 106, 109–110, 131, 138, 141–142, 144–150, 184
New York, 127
Nganga, 104–109, 114
NGOs, 26, 109, 165–166, 178–179
Nguva, 48
Ngwangwa, 51
Nhariríre, 52
Nhovo, 51
Niger, 13, 48, 58, 163
Niger-Congo, 48
Nigeria, 13, 20–22, 26–27, 67, 105–106, 122, 131, 138, 140–144, 146–150, 173, 181
Nile, 40–41, 47
Njanja, 76
Nkisi ndoki, 25
Nokia, 111
Nollywood, 27, 149–150
Non-European, 7, 15
Non-Western, ix, 4–5, 63, 70, 73, 77
Normal science, 3
North Africa, 7, 58, 151, 153, 163, 165
North Korea, 57, 59
Novel, 8, 36, 81, 88, 91, 93–94, 114, 149, 175
NSI, 171, 173–175
Nummo, 122
Nurture, 117, 123, 135
Nyamafingu, 56
Nyame, 122
Nyamita, 50
Nyanga, 66
Nyanga-Mutare, 57
Nyengo, 69
Nyerere, Julius, 6, 133
Nyikadzimu, 50
Nyongorosi, 53
Nyuchi, 57
Nzvimbo dzedzidziso, 59
Nzvimbo, 10, 48, 59
Nzvimboshandwa, 10

Oakland, 127
Observe, observation, observatory, 3, 17, 32, 38, 52–53, 57–58, 60–61, 63, 70, 91, 100, 104–105, 110, 112–114, 124, 137, 139, 141, 148, 178, 182–183, 185
Obsolescence, 127, 144
Occult, 103, 107
ODA, 26, 152, 160–163
Odhiambo, Atieno, xii, 42
Odhiambo, Thomas, xii, 42
OECD, 9, 157, 161, 170–171, 180, 183
Ogaranya, 11
Ogo, 122
Open defecation-free status, 166
Open-source, 111, 124–125, 129–131
Ordinary people, 9, 18, 23, 46–47, 82
Orin, 20

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Orthogonal, 130, 134
Osiris, 41, 192
Oslo Manual, 9, 171, 180–181
Osseo-Asare, 5, 7, 133, 213
Overdimensioning, 26, 146–147, 149–150
Ownership, 70, 93, 117–162, 164

Pachoto, 59
Padare, 53, 59
Pan-Africanism, xi
Paradigm, 3, 6, 124, 171–172, 177
Parastatals, 17
Patches, 83, 85, 92
Patent, 8, 59, 76, 124, 172, 181, 183–184
Peer review, 3, 58, 61
Performative research, 83
Pfuko, 72
Pfumo, 51
Pfungwa, 57, 60, 62
Phone, 18–19, 21, 36, 102–103, 105, 111, 137–139, 141–143, 145–147, 150
Plants of bondage, 24, 79, 81–83, 85–89, 91, 93, 95
Platform, 11, 13, 15, 18–21, 54, 63, 65, 67, 75, 110, 112, 130, 132, 137
Point-of-use innovation, 25
Policy, xiii–xiv, 9, 27, 130–131, 146, 169–170, 172–177, 179–185
Policymaking, policymakers, 27, 173, 177, 180, 182–183
Political economy, 117, 134
Polysemy, 98–99, 109, 114
Population, 18, 73–74, 76, 102, 153, 175–177, 183
Portable, portability, 142–143
Portland, 27
Postcolony, postcolonial, 5, 7, 18, 64, 70, 100, 113, 123
Postindustrial, 9
Pot bellow, 69
Pottery, xii, 10, 13, 24, 48, 60, 64, 68, 70–77
Poverty, 5, 24, 53, 134, 154, 158–159, 163, 165, 169–170, 174–175, 180–181, 183–185
Practice, x–xii, xiv, 2–3, 5, 7, 9–11, 13, 15, 23–26, 36–44, 52, 58–60, 62–65, 70–73, 75–77, 81–82, 88, 91, 94, 97–99, 102–105, 111–112, 114, 121, 123–124, 127–133, 138–140, 146–150, 166, 171–178
Pre-European, 63, 65, 67, 69, 71, 73, 75, 77
Prescience, 3
Primary, 10, 18, 65, 69, 76, 117, 144, 153–159, 167
Primitive, 5, 77
Private ownership, 117
Privatize, 17, 124, 160
Problem-solving instruments, 27
Producer, 4, 13, 22–23, 71, 76, 95, 114, 139, 149, 179
Producing knowledge, 74, 139
Productive, 22, 40, 42, 44, 58, 80–81, 91, 93, 135, 139–140, 148, 157
Professoriate of (indigenous) knowledge, 10, 12, 59
Progress, 4, 9, 15, 34–35, 67, 73, 77, 113, 181
Proverbs, 22, 35, 52–55, 58–60

QAMP, 128, 132–133
Quilombos, 80, 93

R&D, x–xi, 9, 19–20, 22, 25, 27, 29, 128, 130, 132–133, 171–175, 177, 179–183
Race, ix, 7–8, 23, 84, 92, 102, 111, 174
Racist, racism, 5
Radio, 4, 19, 102–106, 113, 114, 146
Rajasthan State, 166
Rationalization, 17–18
Raw material, 5–6, 9, 19, 70, 72, 74
Redistribution, 117, 134
Register, x, 5, 7, 46, 81, 113, 144
Research, xii–xiv, 5, 8–9, 11, 19, 44, 60, 63, 67, 70, 80, 83, 92–93, 97–97, 100, 102, 104, 128, 130, 139, 142, 151, 157, 170–173, 175–176, 178–180, 183–185
Resistance, 16, 36, 82, 91–93, 139
Re/trans, 89, 93–94
Reuse, 25, 129

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Risk, 2, 11, 15, 54–55, 134, 162, 181
Risk management, 55
Ritual, 38, 65, 72, 74, 87, 122
Riva, 51
Robots, 25, 101–103
Rongo, 72
Runyanga, 49
Runyararo, 55
Rural eMarket, 21
Rusvingo, 51
Ruzivo rwechokwadi, 61
Ruzivo, 46, 51, 59–61
Rwanda, 18, 109–110, 113, 115, 163
Rwavhi, 55
Rwayitare, 18–19

S&T, 27, 169, 172–174, 177, 179–181, 183
Sacred, 34, 50, 88–89, 92–104, 121
Sacred animal, 50
Sadza, 48, 72
Salon d'Innovation, 100–101
Salt, 12, 12–13
Salt production, 12
Salvage, 128
Samasimba, 48
Sambaza, 36
Samsung, 102, 111
Sanitation, 26, 100, 155–160, 162–164, 166, 185
Sao Tome and Principe, 163
School, xii–xiii, 3, 10–11, 17–18, 21, 23–24, 27, 29–30, 36, 81, 98, 104, 106, 113, 131, 149–150, 157, 166, 177
Science, Technology, and Innovation Strategy for Africa (STISA), xiv–1, 169–170, 181–182, 185
Sciences, xii, xiv, 80, 84, 87
Scientific innovation, 74
Scientific method, 2–3, 58
Seattle, 127
Security, 14, 18, 23, 34, 49, 52, 56, 61, 155–156, 158–159, 170
Self-liberation, 46, 82
Self-mortification, 22–23
Self-worth, 100, 107
Selfie, 140, 144, 150
Senegal, 25, 128–129, 133, 163
Senghor, x, 6, 133
Shaka Zulu, 76
Shambakodzi, 72
Shangwa 55
Shangwe, 56
Shape, 24, 40, 63, 70, 72, 92, 108, 121, 139, 141, 149
Shashiko, 50, 61
Shato, 51, 55
Shavé, 51
Shelter, 155, 158–159, 162
Shona, 23, 45, 47–48, 50, 52, 55, 57, 69, 72, 75–76
Sierra Leone, 163
Signaling traffic, 145
SIM card, 111–112, 141, 143
Simfy Africa, 20
Site of production, xii, 7, 74
Six-legged biochemical weapon, 57
Skepticism, 58
Slavery, 5, 9, 80–81, 83, 86, 91–92, 94–95
Slave trade, 11, 94–95
Smart, 20–21, 24–26, 97–99, 101–103, 105, 107–115
Smart cities, 25, 99, 113
SMEs, 171
SMS, 21
SNEL, 100, 102
Socialism, xi, 17–18, 59, 99, 103, 113, 117, 121, 124–125, 134
Society, ix–x, xii–xiii, 1, 3–4, 6, 8–9, 12, 30, 34–35, 51, 59–60, 63, 70, 74–75, 95, 97–98, 106–107, 112, 114, 117, 138, 149–150, 154, 167, 170, 179–180, 183, 185
Sociotechnical, 25, 73, 124, 171
Sociotechnical assemblage, 25
Soft power, 61
Software, 109, 111, 124, 126, 131, 138
Songhai, 57
South Africa, 15–17, 19–20, 69, 71, 74–75, 94, 99, 109, 146, 148, 173, 180, 184

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Soviet Union, 47, 59, 134
Spinlet, 20
Spirits, 24, 47–48, 51, 61, 97, 103, 106, 108, 121
Spiritual, 3, 20, 23–25, 39, 45–47, 50, 61–62, 82, 98, 103–105, 107–108, 117–118, 121–122, 129
Spiritual knowledge, 24, 98, 104
Spiritually guided warfare, 45, 47
Spiritual meaning, 50
Sussex Policy Research Unit (SPRU), xiv, 174, 185
Standard, 97, 143–144, 146–148
Startup, 11, 129, 131, 220
State, ix, xi, xiii–xiv, 3, 8–9, 12–18, 23, 26, 37, 44, 48, 53, 58–60, 75, 81, 91, 94, 99–101, 109–110, 112–113, 118, 124, 127–129, 134, 137–138, 141–144, 150, 152, 154, 164, 166, 169, 182, 184
STEAM, 133
Steel, 17, 75, 112, 151
STEM, 177
STI, 1–2, 4, 9, 23–24, 27, 169–185
Stockholm Convention, 43
Strategic deployment, ix, xi, 5, 19
Strategic innovation, 151–152
Strategic targeting, 26–27
STS in Africa, 79
Suame Magazine, 132–133
Subaltern, 5
Sudan, 12, 40, 47, 69
Survival, 12, 24, 69, 89, 91, 93, 105, 108
Sviba, 49
Svikiro, 49
Sweden, Swedish, 148

Tanzania, 16, 19–20, 31, 37, 44, 48, 106, 109, 121, 133–134, 151, 163
Techne, 3, 104, 106–107, 113
Tech Needs Girls, 131
Technique, 12, 40–42, 44, 58, 68, 71, 83, 86, 88, 101, 104, 109, 132–133
Technological imagination, 6, 79, 80
Technological infrastructure, 105, 113, 137
Technological innovation, 8–9, 12, 41, 64, 67, 97–99, 113, 127
Technological leapfrogging, 26, 142
Technological style, 68
Technologies, 5, 7, 9, 19, 21, 64–65, 68, 70, 73, 76–77, 81–82, 87, 91, 93–94, 99–101, 103, 110–111, 113–114, 130–133, 138–143, 149
Technology, ix–11, 13–14, 18–19, 24–25, 27, 29, 31, 33–37, 39–41, 43, 45–47, 60, 63–66, 70, 73–74, 77, 79, 81, 97–100, 102–126, 129–132, 137–140, 142–144, 149–150, 164, 166, 169–171, 173–175, 177, 179–181, 183–185
Technoscience, technoscientific, 5, 112
Telecel, 18
Telecommunication, 18, 19, 141, 142, 148
Television, 19, 101, 103, 107, 114
Terrorist, 47
Test, 2–3, 6, 17, 19, 27, 36, 43, 58, 60, 68–70, 91–93, 109, 111, 114, 121, 123–124, 128, 132, 141, 173
Theory, x, 3, 22, 60, 75, 77, 106, 121, 139–140, 147, 171
Things, ix, xi, xiv–1, 4–5, 7–8, 15, 19, 23, 25–27, 31, 34, 51, 53, 62, 74, 77, 82, 87–88, 92–93, 98, 108, 110–111, 133, 144–145, 150
Thought, x–xi, 3, 23–24, 29–30, 38–39, 41, 58, 60, 62, 64, 80, 83, 88–89, 92, 97
Thought collective, 3, 58
TIM, 177
Time, xii–1, 10–11, 15, 17–18, 23–24, 27, 29, 31, 34–35, 37, 39–42, 44, 48, 52, 55–57, 59, 63, 65–66, 76–77, 79, 82, 93, 105, 113, 128, 130–131, 146–147, 150, 156–157
Tinkering, 7
Togo, 67, 121, 163
Tondibi, 58
Tool, 4–6, 10, 15, 25, 29–32, 34–36, 41, 43, 90, 97–99, 102–104, 106, 109, 114, 127, 130, 150, 164, 174, 177
Tools of empire, 4, 200

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Tovela, 48, 61
Tradition, ix, 7, 16–17, 20, 22, 25, 27, 30, 33–35, 39, 42–43, 47, 49–50, 53, 56, 58, 61, 74, 82–83, 90, 93, 103, 117–119, 121–124, 128, 132–133, 135, 139, 143, 146–150, 164, 178, 180, 184
Traffic profile, 147–148
Transient workspace, 10, 12, 59–60
Transparency, 164
Trans-Saharan trade route, 11–12, 41, 76
Trial and error, 8, 58, 65, 68, 76, 105, 114, 123–124
Trivialization, 23
Tsenzi, 53
Tsetse, 16, 57
Tsinga, 57, 60
Tsomho, 51
Tsvimbo, 51, 61
Twitter, 20

Ubongo, 108
Uganda, 14, 16–17, 117, 163
Ujamaa, 134, 212
Ukano, 51
Ukutshona, 52
Umbimbindoga, 51
Undersea cables, 19
Unemployment, 170, 175, 177, 180
United Kingdom, 44, 137, 185
United Nations Environmental Program, 43
United States, 9, 18, 26, 59, 110, 127–129, 137, 141, 143–144
Universalism, 58
Unscientific, 3, 64
Uropi, 60
Urwere, 55
Use, ix, 4, 7, 12, 20–21, 24–26, 35–37, 39–43, 52, 54, 56–57, 61, 64, 66, 68–70, 72–73, 75, 80, 83, 85, 87, 94–95, 103–106, 108–109, 114, 117, 121, 124, 129–130, 132–133, 138–139, 141–143, 147–148, 150–151, 160–161, 163–167, 174, 181–183
Useful arts, 4
User, 26, 69, 106, 143–148, 150, 171
Using, ix, 21–22, 46–47, 61, 63–65, 68, 70, 72, 74–76, 82, 86, 90, 94, 110–112, 124, 127, 130–131, 133, 137, 139, 146–147, 153, 158, 164, 166–167, 178, 180
Union of Soviet Socialist Republics (USSR), 117
Ùtá, 51
Uttar Pradesh, 164

Vadzidzisi, 59
Value extraction, 134
Value flow, 124–126
VaMhani, 50
VaMhari, 50
VaNyemba, 49
Vari kumhepo, 51
Varozvi, 48, 56–57
Vasekuru, 50
VaShawasha, 49
VaTsunga, 50, 57
Vazukuru, 50
Vendor, 25–27, 102, 129, 160
Venyama, 51
Vernacular, 7, 29, 46, 147
Victim, 5, 7, 35, 47, 55, 61, 98
Vietcong, 57
Visionnaire, 110
VLR, 145
Visual arts, 80, 86–87, 91
Visualized knowledge, 83
Vodun, 121–122
Voice channel, 145, 147
Voice traffic, 145
Voodoo, 121
Vuga, 20

WaDImena, 163, 165
Warrior, 12, 31, 34, 50–51, 61, 104
Waste, 25, 65, 68, 128–133
Water, xii, 12, 24, 26, 30, 35, 40–42, 50, 52–54, 61, 69–70, 72, 94, 100, 118, 122, 153–167, 170, 185

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Watsan, 157, 162–164
West, the, 9–10, 1–2, 4, 8–9, 19, 33, 35, 37, 41, 58–59, 64–65, 70–71, 73–73, 81, 112, 118, 121, 124
Western, ix–xi, 1–9, 16, 22–27, 33, 37, 40, 46, 58–61, 63–65, 69–70, 73, 75, 77, 99, 112–113, 119, 121, 151, 164, 172–173, 179
Western laboratory, 61, 64
Western science, 2, 5, 58, 61, 64, 69
Whatsapp, 20–21, 112
White technology, 7
Whole Village Development Model, 166
Wired, xi, 22, 26, 112
Wireless, 26, 110, 113, 138, 142–144
Wisdom, 22, 24, 98, 104
Witchcraft, 25, 44, 106
With knowledge, 24, 42, 72, 98, 106
Without knowledge, 106
WoeLab, 25, 130
Wolof, 129
Wongororo, 58
Workshop, xii–xiv, 10, 77, 95, 131
World Bank, 9, 17–18, 35, 154, 161–166, 170–171, 180, 185
World War, 58, 149, 174

Yankee, 108, 111
Yemen, 166
Yookos, 20
Youth, 94, 107, 109, 112

Zambezi, 50, 56, 69
Zambia, 19, 68, 121, 123, 163
Zimbabwe, xi, xiii, 9, 16–18, 21, 23, 45, 48, 50, 53, 57, 63, 66, 67, 69, 72, 75–76, 106, 140, 152
Ziscosteel, 17
Ziwa, 48
Zulu, 15–16, 76
Zulu entrepreneurs, 16
Zvakatikomberedza, 46
Zvidobi, 51
Zvirahwe, 60
Zvisikwa, 49, 59
Zvisikwa zvamwari, 59
Zvombo, 51, 60
Zvombo zvemurume, 51

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